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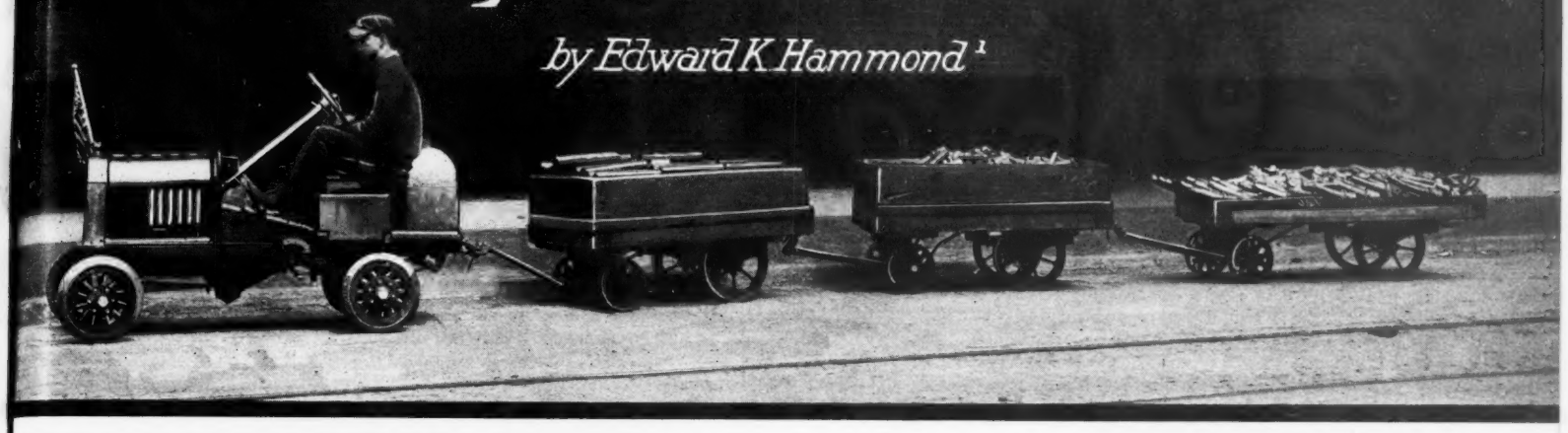
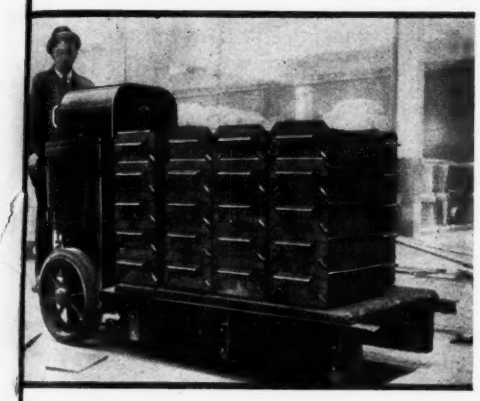
Factory Transportation

by Edward K Hammond[1]



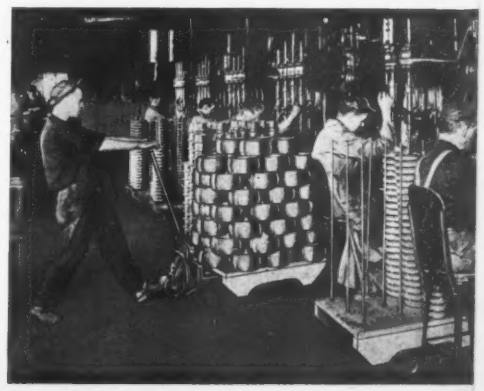


IN order to obtain the maximum efficiency in manufacturing it is essential for all the men and machines in a plant to be kept constantly supplied with work. No matter how cleverly methods of machining may have been worked out, nor how suitable the mechanical equipment may be, a satisfactory rate of production cannot be hoped for unless there is a uniform supply of raw material or pieces in course of production to keep all the machines and operators constantly at work. In studying conditions in a variety of manufacturing plants engaged in the production of many different kinds of work, it frequently becomes apparent that there is loss of production and profits due to the management's failure to appreciate the importance of this point. In such plants production may be high for periods of considerable duration, but due to lack of foresight in anticipating some unusual delay, a whole department may be held up for some time because of failure to bring a supply of work from one of the preceding departments.

Efforts made by manufacturers to reduce production costs in order to meet competition and make profits have led to many improvements in manufacturing operations. But in many plants where great care has been taken to develop efficient methods of manufacture, the same attention has not been paid to developing methods of transporting material and product through the factory. Obviously, this is poor management, because any delay in the delivery of work to machines results in non-productive time for both machines and their operators. It is the purpose of the present article to describe various methods of lifting and transporting material and work in course of production. A study has been made of methods of handling work which are used in leading industrial plants, and the article is based upon the result of this investigation.

Cooperation between Management and Workers

To successfully solve the problem of transporting material and product through an industrial plant requires a detailed study of manufacturing conditions in that plant made by experienced industrial engineers who are capable of recommending those forms of equipment best adapted to meet the requirements found. But there is one condition which the industrial engineer cannot control, namely, the intelligent use by workmen of the equipment provided. Cooperation between the employes and management of



A—Train of Cars hauling Forgings to Machine Shops of Timken-Detroit Axle Co. Special Tractor equipped with Motor of Ford Automobile
B—Elwell-Parker Electric Storage Battery Truck hauling Load of New Britain Tote Boxes filled with Steel Balls at Plant of New Departure Mfg. Co.
C—Buda Electric Storage Battery Truck hauling Load of Gears up Incline; Batteries mounted beneath Truck Platform to give Additional Loading Space
D—Barrett-Cravens Elevating Truck delivering Load of Stock to Power Press Operator; Stand raised so that Operator reaches Work without stooping
E—National-Chapman Elevating Truck in Headstock Assembling Department of Jones & Lamson Machine Co.
F—Motor Truck with Detachable Body being lifted from Truck by Trolley Hoists which will carry Load into Plant
G—Cowan Elevating Truck used in Connection with Special Stands for holding Pieces with Hole in Center

[1]Associate Editor of MACHINERY.

an industrial plant is of primary importance in order to handle material with the maximum rapidity, and various methods of securing such cooperation have been adopted, the most successful of which is some form of bonus system. Where carefully planned methods of handling material and conducting machining operations have been worked out in sufficient detail to include giving definite instructions concerning the method of handling each piece, and where the incentive to follow these instructions is created through payment of a bonus to efficient workers, some marvelous production records have been made, and in this connection it is noteworthy that these results have been secured through the development of common-sense time-saving methods of working, and not through the expenditure of extraordinary effort on the part of the men. For the manufacturer who realizes the necessity of improving his operating conditions, the bonus system is worthy of most careful consideration, as the incentive offered a man to work for higher wages will be more effective than trying to make him work by any direct form of supervision.

How Factory Lay-out Affects Transportation Problems

Every year industrial engineering becomes a more complex profession, because constantly increasing competition between manufacturers leads them to rely upon the industrial engineer to suggest methods of reducing production costs which would either have been considered too complicated to justify their adoption under conditions that existed a decade ago, or which were seemingly of so trivial a nature that it took time to make apparent the savings that might be effected through their use. One of the most obvious methods of facilitating the work of handling materials and products, and one which has been made the subject of frequent comments in the technical press, is to arrange all the departments in a factory and all the machines in each department so that the work follows a continuous route through the plant without the expenditure of unnecessary time and labor in carrying it back and forth. A great deal of profitable work has been done in rearranging the lay-out of departments in factories and of the equipment in departments in order to provide a continuous route over which materials are carried without the necessity of long hauls between departments, and to avoid the congestion which is likely to arise when the same aisles have to be used by trucks which pass in opposite directions.

One simple expedient, which is capable of producing a marked increase in efficiency in handling materials and products on trucks, is the maintenance of open aisles in all departments and in passageways connecting different departments of the plant. This point is often entirely overlooked by the management of factories which otherwise show ample evidence of efficiency. Such shops frequently have the aisles so cluttered up with a heterogeneous collection of materials, products and tools that it is virtually a case of "breaking a trail" for a truck that must be pushed through the shop. In many factories where a decision has been reached in favor of maintaining open aisles, the aisles are marked on each side by a white paint line; but men in a shop are only human, and if some advantage may be secured by having a box or bar of steel extend slightly over the aisle line, or if it is easier to pass another truck by running the wheels of a truck a little way into the part of the shop reserved for strictly manufacturing operations, it is not probable that the white paint line will have any great restraining influence. While these may seem trivial infractions of rules, they are likely to cause serious delays if allowed to go unheeded. Realizing this fact, the Timken-Detroit Axle Co., Detroit, Mich., adopted an expedient which has proved of material value. Down each side of all aisles in the factory, two- by four-inch scantlings are nailed to the floor, and they are protected by angle-irons, so that they are not subject to damage by truck wheels, etc. They are painted white so as to be always visible, and have been found an effective means of preventing minor accidents and delays caused by trucks intruding upon space in the factory reserved for manufacturing work, and also of preventing machine operators from pushing boxes of castings or partially finished work out into the aisles where they block the progress of trucks carrying work from department to department.

Rearrangement of existing plans is well worth while. We have in mind one small factory engaged in the manufacture of machine tools which has recently increased its output over 50 per cent by completely rearranging the lay-out of departments and equipment, without buying any new machinery or hiring more men. But in cases where complete new plants are designed, built and equipped for the production of a specified quantity of work, it is possible to obtain far greater efficiency than where existing factories are remodeled with the view of increasing efficiency. This is because, under the best conditions, rearrangement of an existing plant must leave many features that could be greatly improved, while in case an entire plant is laid out on a drawing-board before starting construction, every detail can be carefully considered and means provided for overcoming many difficulties which are foreseen by the industrial engineer as a result of his experience with similar problems in other factories. In the automobile industry we probably see some of the best examples of efficient methods of handling work. Viewing the subject broadly, there are several explanations which may be offered for the high degree of efficiency which has been attained in this industry, but they may be narrowed down to the fact that many of these companies have been organized and their factories have been built to provide for securing a specified rate of production, and in this industry, as in no other, has the advice of the best industrial engineering talent been taken in regard to the installation of time and labor-saving appliances. A plant that is required to make and assemble the parts to turn out several hundred complete automobiles a day is certainly faced with a great task, and were it not for the fact that the automobile industry has taken advantage of every possible means of increasing production, it would have been a physical impossibility to meet the demand for motor cars that has existed during recent years.

Analysis of Transportation Problem

Handling of material and product in industrial plants is subject to a fundamental sub-division according to whether the material is to be lifted into position on a machine or to a higher floor in the building, or whether the object is to carry the work to some other part of the factory. A variety of equipments are used for both lifting and carrying work, but these overlap each other to a considerable extent, so that in the following lists, which show the different types of equipment in general use, it will be seen that considerable duplication exists under the heads of "lifting" and "transporting." An interesting phase of this problem, although it is one that offers grounds for considerable complication, arises from the fact that many different types of equipment are used for exactly the same classes of service, so that selection of the best form of equipment to meet a given set of conditions is dependent upon a number of factors. Chief among these are the volume of material to be handled, first cost of equipment suitable for that purpose, and the labor and overhead expenses incident to operating under these different systems of transportation. This subject will receive further consideration in a later part of the article, but at this time the point may be made clear by comparing conditions in two shops which are machining a piece weighing, say, ¼ pound, but where one shop produces 500 pieces a day while the other is required to turn out 100,000 pieces a day. In selecting means of handling this work the small shop could probably do no better than decide to adopt the use of boxes carried by elevating trucks; but the large production of the other shop would call for an excessive number of trucks and men to pull them, and aside from the high labor cost incident to the adoption of such a system, laborers employed on this work would certainly create considerable congestion in the plant. For these reasons the experienced industrial engineer would probably adopt the use of some form of conveyor system for handling the large output of the shop.

Factors Governing Selection of Motor-driven Hoists and Chain Blocks

When a manufacturer or his engineer is selecting hoists to be used for lifting material or parts in course of manufacture or for transferring them to some other point in the shop, he

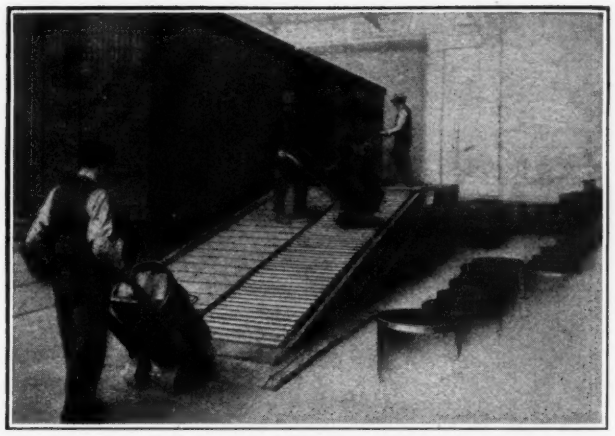


Fig. 1. An escalator is used in plant of Chain Belt Co., Milwaukee, Wis., for carrying men and loaded trucks to platform from which trucks can be wheeled into freight car. Three men are shown in successive positions, and it will be seen that escalator for trucks is provided with cleats to prevent wheels from slipping

Fig. 2. Where hand trucks are used in factories with swinging doors between departments, it is common practice for truckers to open doors by bumping truck against them. The Timken-Detroit Axle Co. found this practice was destroying doors, and overcame the difficulty by providing each truck with a semicircular buffer

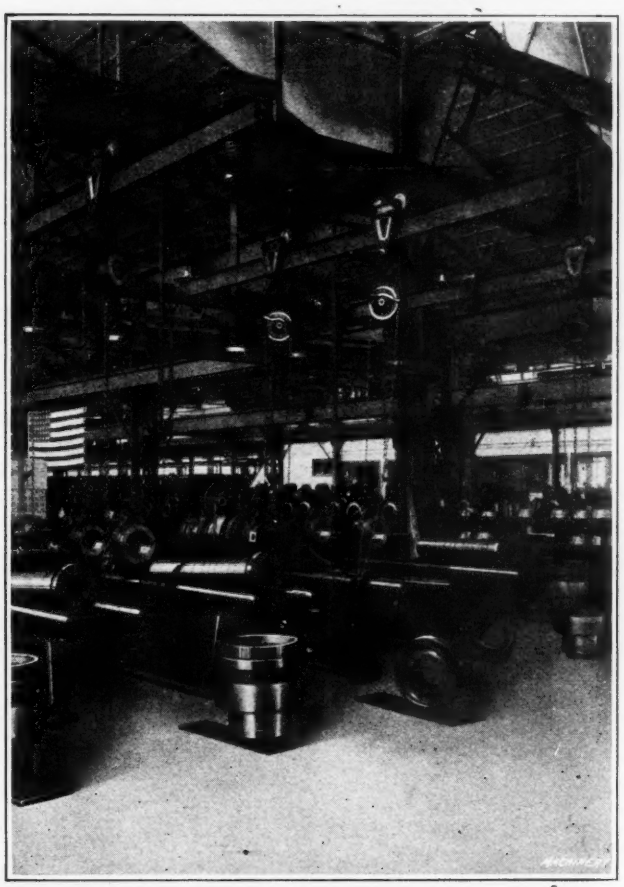


Fig. 3. Where the distance a load is to be carried is too great for a swinging jib crane, advantageous use is often made of the so-called "wall" type of crane, in which a cantilever beam is supported by a truck at one end. The truck wheels run on rails secured to the wall. Wall cranes are used to advantage in the Gisholt Machine Co.'s factory

Fig. 4. Under efficient management, a point will be made of having each hand truck carry approximately the maximum load which a man can push on a level floor. With such practice it will ordinarily be required to provide extra labor to help men push trucks up an incline. Here a Yale & Towne triplex hoist and trolley is used to raise the truck

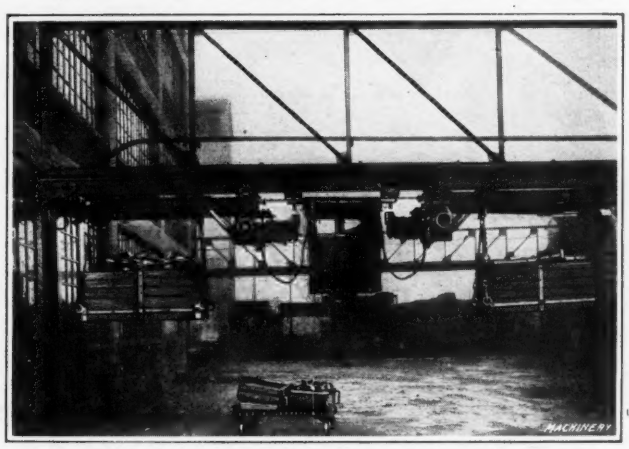


Fig. 5. Where it is desired to transport small pieces on trolleys, it is necessary to equip trolleys with a carrier in order that a load approximating the trolley's capacity may be carried at each trip. This view in the Ford Motor Co.'s plant shows trolleys with carriers for handling small castings, built by the Sprague Electric Works, New York City

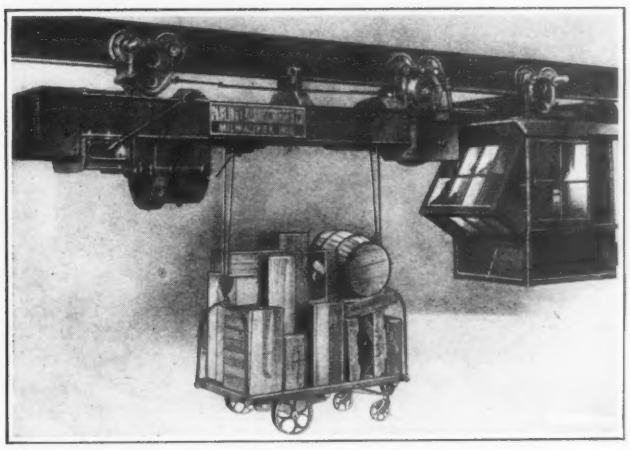


Fig. 6. Sometimes a truck load has to be moved a considerable distance. To save time, it may be found good practice to pick the loaded truck up from the floor by means of a trolley and carry entire load through shop in this way. A monorail crane built by the Pawling & Harnischfeger Co., Milwaukee, Wis., is shown handling a loaded truck in this manner

Fig. 7. Where proper care is taken in laying out shop equipment, it will often be possible to group machines so that one jib crane and trolley will be able to serve a number of machines. In this illustration a view is shown in the Gisholt Machine Co.'s factory, where one jib crane is able to serve as many as five machines

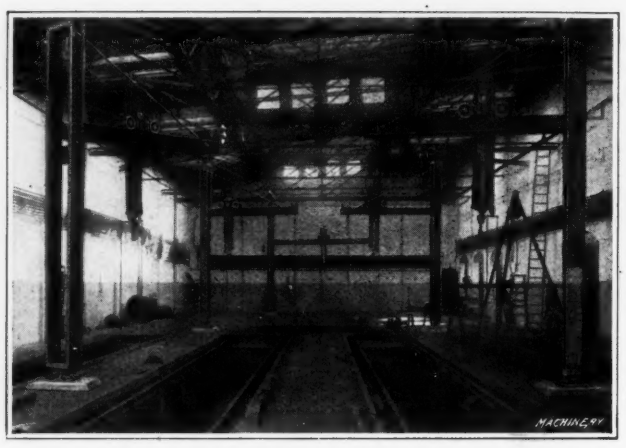


Fig. 8. Where there is plenty of head room, traveling cranes, jib cranes and trolleys may be equipped with vertical air cylinder hoists. Only in cases where head room is limited is it considered good practice to place the cylinder in a horizontal position. This illustration shows Vulcan Engineering Sales Co.'s Q.M.S. air hoists in use in a car shop

has a choice between the use of a hand-operated chain block or a motor-driven hoist; similarly, the type of trolley which he decides to use may be motor-driven or hand-operated. There are numerous factors governing the selection of the type of equipment for a given installation, but, generally speaking, it is a case of balancing first cost and depreciation charges against efficiency of operation. Where motor drive is used for operating both hoist and trolley, it is obvious that the equipment will cost more than where hand chains are used for performing both these functions, and as the motor-driven equipment has a more complicated mechanism, depreciation costs will be greater than in the case of the hand-operated hoist and trolley.

To offset these limitations, attention is called to the fact that motor drive enables hoisting and transfer of material to be performed more rapidly than it can be done with hand-operated equipment. Also, the use of electric motors is likely to be the means of effecting a material increase in production for the following reasons: (1) The work is done more rapidly. (2) The workman is not unduly fatigued, and so there is no marked falling off of his efficiency during the latter part of the day. (3) The workman does not hesitate for a minute or so before applying himself to the work of raising a load by hand. The third reason is what might properly be called psychological, but the results of time studies show that it is really important, because when a man begins to tire during the late afternoon he is likely to waste several minutes before applying himself to the work of lifting and transferring a heavy load by the manipulation of hand chains, whereas no particular exertion is required to pull the cord governing hoisting or traversing motors.

In addition to trolley hoists in which both trolley and hoist are motor-driven or in which both are operated by hand, equipments are built in which the hoist is motor-driven and the trolley hand-operated, or *vice versa*. In many shops insufficient attention is paid to the selection of the trolley hoist

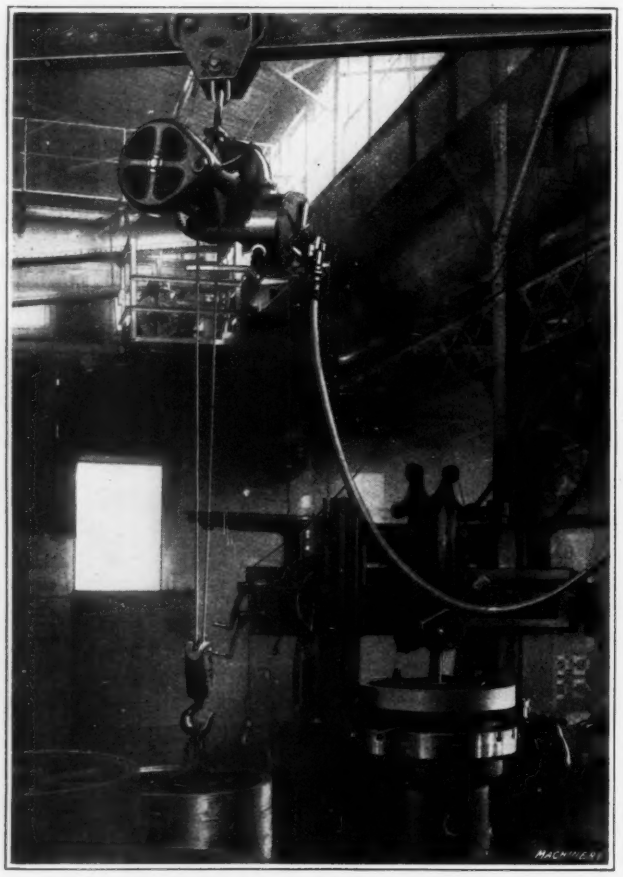


Fig. 9. Work handled on boring mills, planers and other heavy-duty machine tools is often of such size and weight that it is impossible for the work to be lifted by hand. It is necessary to provide means for lifting work and placing it on the machine table. A hoist and trolley facilitate handling lighter pieces. This illustration shows use of an Ingersoll-Rand "Imperial" pneumatic motor hoist and trolley

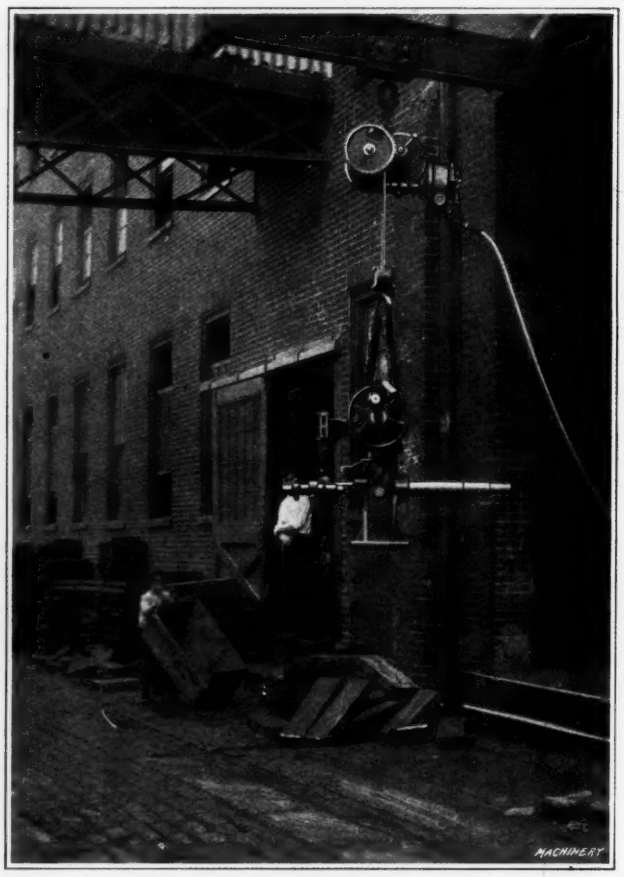


Fig. 10. Where heavy materials come to a plant by railroad or motor truck and a trolley system is used for carrying them to various departments in the plant, it will be found good practice to have a beam extending out over the railroad or roadway, with an extension of the trolley rail supported on this beam. This illustration shows such an arrangement, with an Ingersoll-Rand "Imperial" hoist and trolley

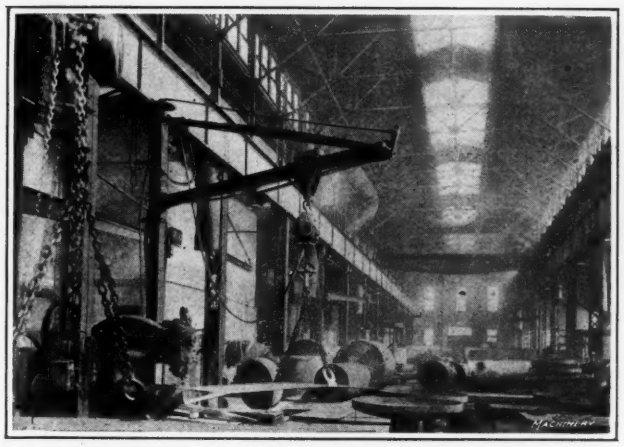


Fig. 11. Where large pieces of sheet metal are to be worked on punching or shearing machines, a trolley hoist will be found convenient to assist in handling the work. This illustration shows a jib crane and pneumatic motor hoist, built by the Chicago Pneumatic Tool Co., Chicago, Ill., in use at the plant of the Duluth Boiler Works

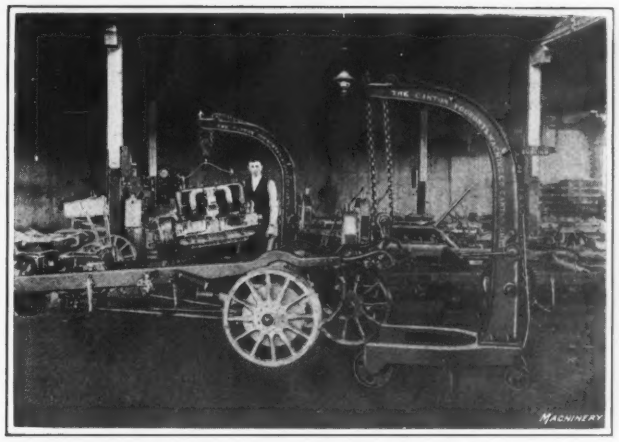


Fig. 12. Portable cranes are used for many purposes. Their chief field is for lifting work in confined spaces that cannot be served by traveling cranes or trolleys. They can also be used to advantage where there is not enough work to warrant installing a crane or trolley system. Canton Foundry & Machine Co.'s portable cranes are shown in use in a garage

equipment best suited for a given class of work, and it is not unusual to see trolley hoists of an unsuitable type responsible for a serious loss in production. In plants where the purchasing agent, who is a non-technical man, is given too much leeway, he is likely to show preference for hand-operated equipment because it may be purchased at a price ranging from one-sixth to one-third that of the full motor-driven outfits. On the other hand, shopmen who are partial to motor drive are likely to select full motor-driven equipment when the higher first cost and maintenance expenses of such an equipment is not warranted by existing conditions.

Legitimate fields for hand-operated and motor-driven trolley hoists overlap to a considerable extent, so that it is difficult to lay down any hard and fast rules governing their selection. In general, it may be stated that where moderate loads are to be lifted at infrequent intervals, and where the distance that these loads are to be carried by the trolley is not great, both hoist and trolley should be hand-operated in order that first cost and depreciation charges on the equipment may be as low as possible. If either the height to which the load is lifted or the distance through which it is carried is considerable, the hoist or trolley should be motor-driven; and if both lift and traverse are considerable, a full motor-driven equipment will probably be found to give the best results. Not only is the motor drive more rapid, but where trolley hoists are used at frequent intervals, the motors offset the otherwise harmful effect of the so-called "fatigue factor," which is the cause of a serious falling off in production in many shops during the latter part of the day.

Electric motor drive gives a hoist from six to eight times the speed of a hand chain hoist, so that this increased rapidity of operation may more than offset the additional price of the electrical equipment. The output of a machine tool is dependent upon the facility with which work is brought to or taken away from it. Large shop cranes may be used to serve machine tools, but it often happens that work which must be performed by traveling cranes is so diversified and distributed that when cranes are relied upon to serve individual

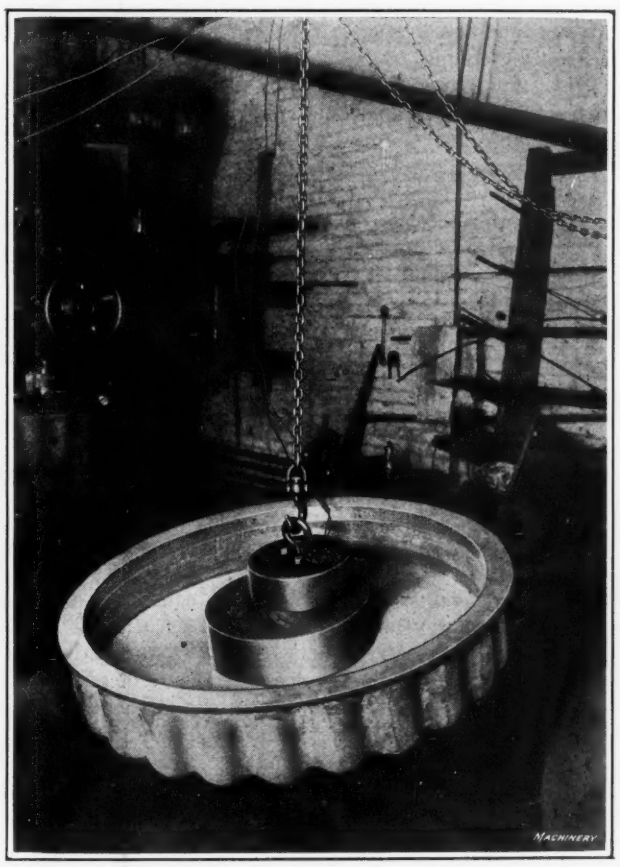


Fig. 13. A hoist equipped with an electromagnet may be used to advantage for lifting heavy castings onto machine tools. This illustration shows a case in which the work to be handled would be difficult to hold with any other form of lifting device. One advantage is the rapidity with which a magnet may be attached and released

Fig. 14. Electromagnets are adapted for handling a great variety of iron and steel products. This illustration shows how coils of wire may be advantageously handled. Anyone who has tried to lift one of these coils knows that it is bulky and hard to hold, but, as shown, a Cutler-Hammer lifting magnet is able to pick up a large number easily

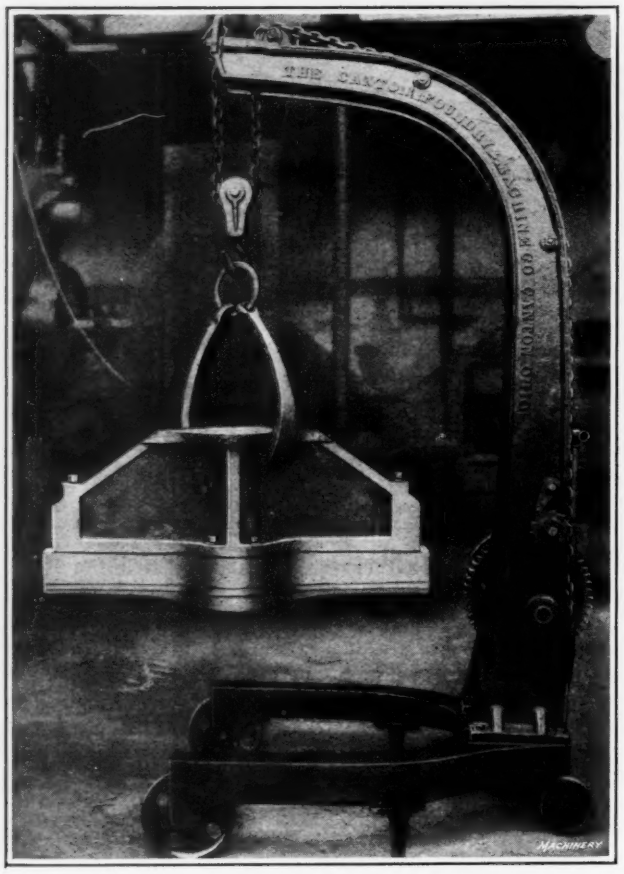


Fig. 15. One class of service for which portable cranes are found useful is in handling heavy castings that must be set up on machine tools and removed after completing the operation. For this purpose their chief advantage is the fact that the load may be placed in almost exactly the desired position. The Canton Foundry & Machine Co., Canton, Ohio, is the manufacturer of the portable crane shown in this illustration

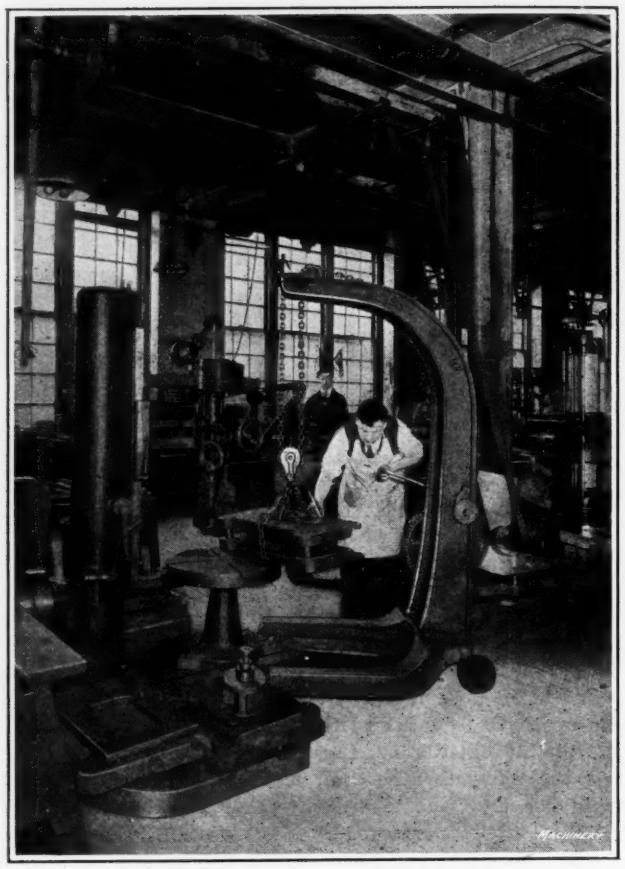


Fig. 16. In setting up heavy pieces on machine tools, it may be difficult to handle work on a traveling crane, due to the inability of that kind of equipment to reach the desired point. This illustration shows a view in the Cadillac Motor Car Co.'s factory, where a portable crane built by the Franklin Machine Works, Franklin, Pa., is engaged in setting up work on the table of a radial drilling machine

tools, waiting for a crane causes frequent periods of idleness at times when it is necessary to change work. This may be of sufficient importance to make it desirable to install individual trolley hoists to serve such machines. A combination of trolley hoists and one or more heavy cranes may also be the means of securing greater returns from the cranes, owing to the fact that they are always available for handling those classes of work for which they are best adapted. Also, with a hoist always available for service, there is a minimum amount of idle time to be charged against the machine and operator.

Under modern conditions of manufacturing, competition has so far reduced normal profits that it is necessary for the management of most plants to analyze carefully their methods of operation with the idea of increasing profits through eliminating all avoidable sources of loss. Three elements largely determine the success or failure of efficiency methods, and these are: (A) Cost of productive labor. (B) Cost of material. (C) Cost of non-productive labor. In many plants item (C), *i. e.*, non-productive labor, could be materially reduced through installing labor-saving machinery for handling materials. The possibility of effecting such reductions is often overlooked, with the result that the overhead expense is unnecessarily large.

Types of Traveling Cranes

Heavy-duty electric traveling cranes are almost invariably made with three motors for operating the hoist and traversing the trolley and bridge, respectively. In the case of traveling cranes for moderate and light work, the equipment may be either hand-operated or of the one-, two- or three-motor type. The conditions governing the selection of one of these four types of equipment are essentially the same as those referred to in connection with hand-operated and motor-driven trolley hoists. A hand-operated crane, in which hoist, trolley and bridge are all worked by hand chains, is used in cases where the distance of traverse is not great and where the crane is used at infrequent intervals. Motor drive is used in any case where the distance which the load is to be lifted, the length of the bridge or the distance that the bridge is to be traversed is great enough to make the saving of time resulting from use of motor drive sufficient to offset the increased cost of equipment and maintenance expenses; and motor drive is also employed in cases where the apparatus is used at such frequent intervals that the assistance rendered by the motors in keeping men working at full efficiency for the complete day is of sufficient importance to more than offset the greater charges which must be made against the work.

Where shops are equipped with compressed air it will often be found economical to employ an air-operated hoist of the cylinder or pneumatic motor type. A choice between three types of equipment may be made, because the cylinder hoist may be arranged with the cylinder in a horizontal or vertical position. Where there is plenty of head room, so that a vertical cylinder hoist may be employed without interference, this will probably be found the most economical form of equipment of the three, because it uses the smallest amount of compressed air. Tables 1, 2 and 3 show the conditions of operation for these three types of hoist.

Use of Transfer Bridges for Shifting Trolleys from One Line of Track to Another

Where trolley systems are employed for moving the material and product in a plant, the usual method is to employ switches for diverting the trolleys from one line of track to another. These switches are easily operated and constitute a satisfactory form of equipment where the number of lines of track is not great. There is a common type of shop construction in which a central bay runs through the middle of the building, with second and third bays extending out at each side; these side bays are generally in a section of the building that is not as high as the central part. A common arrangement in shops of this kind is to have one or more electric traveling cranes in the central bay and trolley systems in the side bays. In many cases there will be a large number of trolley tracks running at right angles to the line of travel of cranes in the central bay. Where such an arrangement is used it may be found practicable to have switches and a line of track running lengthwise to provide for carrying trolleys from one of these cross

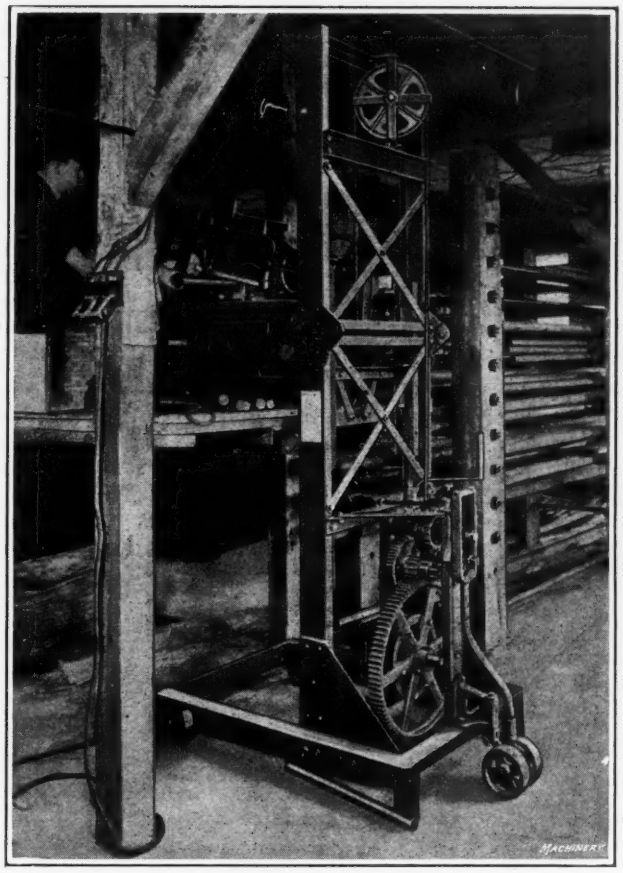


Fig. 17. Not every manufacturer is enterprising enough to install an elevator at his steel stock rack. The Mechanical Appliance Co., Milwaukee, Wis., uses a portable tiering machine built by the Economy Engineering Co., Chicago, Ill., for lifting a hacksaw to the required level so that a bar of steel may be drawn out on the rack and cut off. While this may seem a somewhat complicated arrangement for handling a simple shop operation, it saves time and avoids confusion

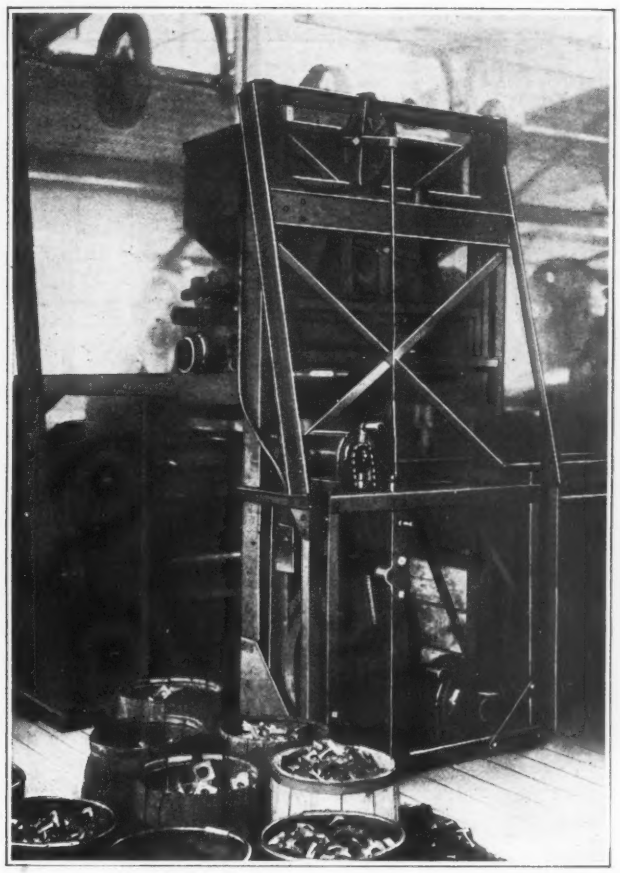


Fig. 18. Loading blank punched nuts into tumbling barrels and removing the nuts and distributing them in bins is heavy work. At the Boss Nut Co.'s factory in Chicago, use is made of a special tiering machine built by the Economy Engineering Co., of Chicago, Ill. It has a cantilever type of platform with two arms which carry the flanged wheels of a small transfer truck. This truck carries rails which support a small hopper-bottom car with a capacity for holding 2000 pounds of nuts

lines of track to another, but if there are a great number of cross tracks, the complication of the switches and trolley system in general will be so great that satisfactory results will not be obtained.

Where such a condition exists, a better practice is to have what is known as a "transfer bridge" running on the tracks provided for carrying cranes in the central bay of the factory. With such a system the bridge carries a section of trolley track which is in line with the cross tracks in the side bays. This bridge and the track carried by it may be run into line with any trolley track in the shop, so that the trolley and its load may be run under the bridge. The bridge and its load are then run down the shop to bring the transfer track into line with the track onto which it is desired to run the trolley. A particular advantage of this system is that it provides for running a trolley from either track in one side bay onto either of the tracks in the bay at the opposite side of the building. Where traveling cranes are used in the central bay, the only way it would be possible to do this with a trolley track and switches would be to have the track extend around the end of the shop, which would involve having the trolley run all around the building to get to its destination at the opposite side, thus consuming an unnecessarily large amount of time; also there would be the objectionable complication of tracks and switches to which reference has already been made.

Use of Lifting Magnets

Magnets are extremely useful for lifting iron or steel because of the ease and rapidity with which they may be connected with the load and disconnected after the desired service has been performed. An idea of the efficiency with which lifting magnets operate and their ability to reduce labor costs will be gathered from the following: The ordinary day's work of a man lifting pig iron from the ground and loading it into a railway car is from 12 to 13 tons per day. Substitution of a lifting magnet for manual labor enables one man, who merely has to operate the controller, to handle about 900 tons per day, *i. e.*, about seventy-two times as much as was accomplished by hand, and thirty times the amount of work possible under the best conditions of scientific management.

Lifting magnets have been adopted for handling materials in a variety of branches of the iron and steel industry. Among the classes of work for which they are used are lifting pig iron, scrap, castings, billets, tubes, rails, plates, crop ends, etc. They are exceptionally useful for loading and unloading cars or vessels. Wherever magnetic materials are to be handled in considerable quantities, the lifting magnet is one form of equipment which should receive careful consideration before determining upon the type of equipment which it is most advisable to install. The load that a magnet will lift depends largely upon the nature of the material to be handled. With a solid mass of iron or steel affording a surface of good magnetic contact, a 62-inch magnet of the type built by the Cutler-Hammer Clutch Co., Milwaukee, Wis., will lift as much as 60,000 pounds, while under very adverse conditions the lifting capacity of the same magnet may drop to 2000 pounds. An idea of the service obtained from a magnet will be gathered from the fact that at an ore dock of the Inland Steel Co., Indiana Harbor, Ind., about 4,000,000 pounds of machine-cast pig iron was unloaded in 10½ hours by two 62-inch old-style Cutler-Hammer magnets, the average lift per magnet being 3427 pounds. Later one of the new style high-duty 62-inch magnets handled 6000 pounds per trip at the same plant.

Types of Equipment Used for Lifting Materials

Hoists, hand-operated; capacity, ⅛ to 40 tons.
Hoists, air, cylinder type; capacity, ½ to 10 tons.
Hoists, pneumatic-motor type; capacity, ½ to 10 tons.
Hoists, electric-motor type; capacity, ¼ to 10 tons.
Cranes, portable; capacity, 1 to 4 tons.
Cranes, jib; capacity, 1 to 10 tons.
Cranes, traveling, hand-operated; capacity, ¼ to 10 tons.
Cranes, traveling, air-operated; capacity, ¼ to 4 tons.
Cranes, traveling, electric; capacity, 5 to 200 tons.
Cranes, traveling, wall type; capacity, 5 to 10 tons.
Elevators, portable; capacity, 4/10 to 1¼ ton.
Elevators, freight; capacity, to suit existing requirements.

TABLE 1. DATA ON PNEUMATIC MOTOR HOISTS

Capacity, Pounds	Feet Lift per Minute, 80 Pounds Pressure	Maximum Lift, Feet	Cubic Feet Free Air per Minute, 80 Pounds
1,000	32	20	45
2,000	16	20	45
4,000	8	20	45
7,000	8	20	80
10,000	7	20	80

Machinery

Means for Transporting Work

Trucks, two-wheeled, hand-operated; capacity, ⅛ to ⅜ ton.
Trucks, hand-operated, elevating type; capacity, ½ to 2½ tons.
Trucks, power-driven; capacity, 1 to 1½ ton.
Trucks, power-driven, elevating type; capacity, 1 to 2 tons.
Trolley system; capacity, 1 to 10 tons.
Conveyor system, gravity type.
Conveyor system, belt type.
Conveyor system, bucket type.
Cranes, jib, hand-operated; capacity, 1 to 10 tons.
Cranes, jib, air-operated; capacity, 1 to 10 tons.
Cranes, traveling, hand-operated; capacity, ¼ to 10 tons.
Cranes, traveling, air-operated; capacity, ½ to 10 tons.
Cranes, traveling, electric; capacity, 5 to 200 tons.
Cranes, locomotive on industrial tracks; capacity, 10 to 20 tons.
Cranes, gantry.
Industrial railways.

In connection with the preceding list of equipments used for lifting and transporting materials, it will be of interest to review briefly those classes of service for which each equipment is particularly adapted. First giving attention to devices used for lifting, the general statement may be made that all types of hoists, portable cranes, portable elevators and jib cranes find application in lifting heavy pieces of work into position on machine tools and for a variety of similar classes of service. The choice of a hand-operated hoist or a power hoist will depend largely upon the magnitude of loads which have to be handled and the frequency of handling. Where heavy loads are the general rule and where such loads have to be raised or lowered through a considerable distance and at frequent intervals, it will be desirable to employ a power hoist to eliminate the fatigue factor, with the resulting reduction in production rates toward the end of the day. When the decision has been reached to use a power hoist, further selection is possible between air cylinder, pneumatic and electric hoists, and here it may be stated that if there is sufficient head room, the cylinder type of hoist will be found more economical than the pneumatic motor hoist, due to its lower consumption of air for a given lifting capacity. The choice between an electric and pneumatic hoist is dependent upon various factors, which may be of greater or less importance in different cases. As a general rule, the question will be decided by the number of hoists to be used, the cost at which electric power can be bought from a generating station, and the relative cost at which electric power or compressed air can be generated in the plant. Each problem has its own peculiar conditions, and in some cases electric hoists will seem preferable, while at other times the use of air-operated hoists will seem advisable. Before leaving this subject it should be stated that where only a few hoists are used or where an air line is not required in the shop for operating pneumatic tools, etc., electric hoists will always be preferable, because it is cheaper to provide connections with an electric power circuit than it is to install air compressors and pipe lines through the shop. Cylinder type air hoists are commonly used where there is plenty of head room, so that the vertical cylinder will not interfere with obtaining the required lift, but where the head room is limited, either a pneumatic motor or an electric motor hoist is more suitable. Another general application of the cylinder type of hoist is in connection with cantilever beams, jib cranes, etc., so that a cable can run from the hoist over an idler pulley; in this way the desired lift is obtained without interference from the cylinder. Of course it will be understood that the lift of a cylinder type of hoist is limited to the length of travel of the piston, unless some form of multiplying rigging is provided to carry the cable.

TABLE 2. DATA ON AIR HOISTS—VERTICAL CYLINDER

	Diameter, Inches	Capacity		Size of Hose Connection, Inches	Cubic Feet of Free Air for 4-foot Lift	
		At 80 Pounds	At 100 Pounds		At 80 Pounds	At 100 Pounds
Brass	4	920	1,150	½	1.83	2.29
Brass	5	1,430	1,790	½	2.84	3.56
Brass	6	2,010	2,510	½	3.25	4.05
Cast Iron	7	2,840	3,550	½	5.97	7.47
Cast Iron	8	3,720	4,650	½	7.81	9.77
Cast Iron	9	4,700	5,875	¾	9.88	12.36
Cast Iron	10	5,700	7,150	¾	11.96	15.00
Cast Iron	12	8,250	10,300	¾	17.31	21.68
Cast Iron	14	11,250	14,050	¾	23.61	29.55
Cast Iron	16	14,600	18,200	1	30.58	38.28
Cast Iron	18	18,500	23,100	1	38.80	48.50
Cast Iron	20	22,800	28,500	1	47.88	60.00

Machinery

Portable cranes find extensive application in lifting heavy castings and other pieces of work from trucks or trolleys and placing them in position on machine tools, etc. The peculiar advantage of portable cranes is that they afford means of adjusting the work vertically to exactly the right height, and of transporting it short distances between trucks or trolleys and machine tools on which operations are to be performed. They reach into cramped spaces where traveling cranes cannot go, and make it unnecessary for a man to get help when setting up a heavy piece of work on his machine.

Jib cranes are used for much the same class of service as portable cranes, and where proper care is taken in the lay-

TABLE 3. DATA ON AIR HOISTS—HORIZONTAL CYLINDER

	Diameter of Hoist, Inches	Capacities						Size of Hose Connection, Inches	Cubic Feet Free Air for 4-foot Stroke	
		Straight		One Sheave, 2 to 1		Two Sheaves, 4 to 1				
		At 80 Pounds	At 100 Pounds	At 80 Pounds	At 100 Pounds	At 80 Pounds	At 100 Pounds		At 80 Pounds	At 100 Pounds
Brass	4	920	1,150	450	565	215	270	½	1.83	2.29
Brass	5	1,430	1,790	700	880	335	420	½	2.84	3.56
Brass	6	2,010	2,510	980	1,225	470	590	½	3.25	4.05
Cast Iron	7	2,840	3,550	1,390	1,740	670	835	½	5.97	7.47
Cast Iron	8	3,720	4,650	1,820	2,280	825	1,090	½	7.81	9.77
Cast Iron	9	4,700	5,875	2,300	2,880	1,100	1,380	¾	9.88	12.36
Cast Iron	10	5,700	7,150	2,800	3,500	1,340	1,680	¾	11.96	15.00
Cast Iron	12	8,250	10,300	4,040	5,050	1,940	2,420	¾	17.31	21.68
Cast Iron	14	11,250	14,050	5,550	6,900	2,620	3,300	¾	23.61	29.55
Cast Iron	16	14,600	18,200	7,150	8,925	3,430	4,275	1	30.58	38.28
Cast Iron	18	18,500	23,100	9,050	11,100	4,350	5,425	1	38.80	48.50
Cast Iron	20	22,800	28,500	11,150	13,650	5,350	6,700	1	47.88	60.00

Machinery

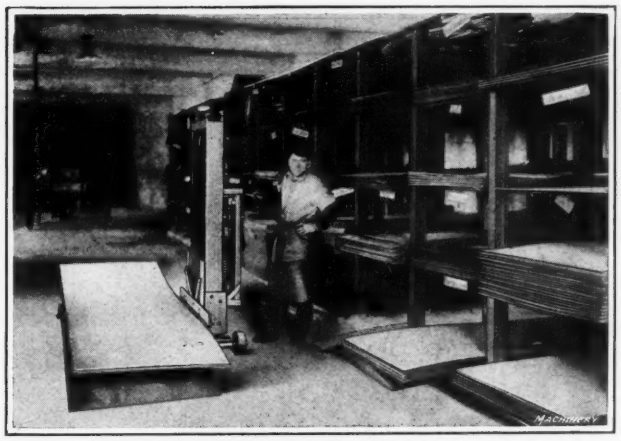


Fig. 19. Bar stock, sheet metal and similar raw materials may be conveniently racked with the assistance of a "revolvator" which is a revolving portable elevator made by the New York Revolving Portable Elevator Co., Jersey City, N. J. Material may be deposited on the elevator platform, raised to the desired level, and turned to any position

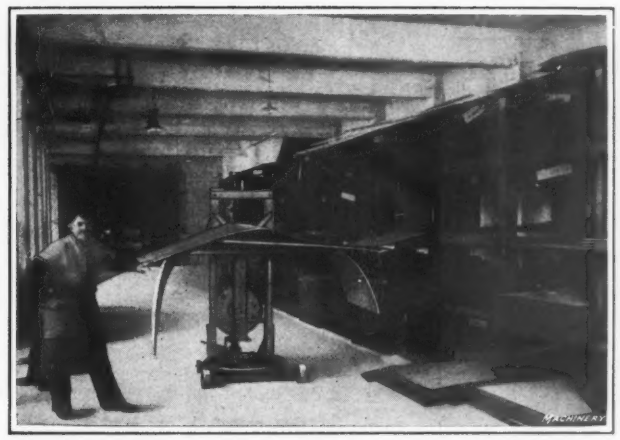


Fig. 20. In the preceding illustration, Fig. 19, the sheet metal has been taken from the wagon and placed on the revolvator platform, with the material running parallel to the length of the rack. Then the revolvator is turned through an angle of 90 degrees and raised the necessary amount, so that the end of the stock comes opposite the desired rack

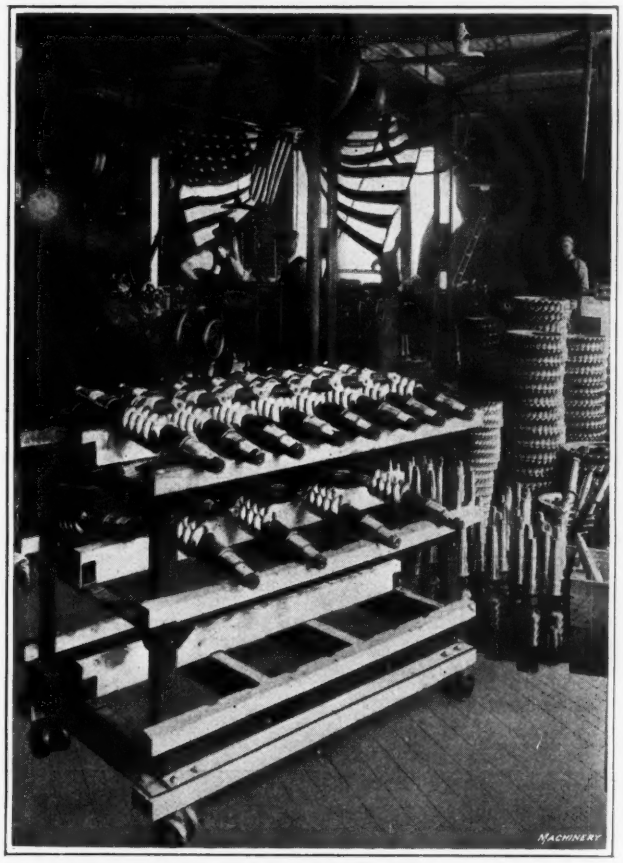


Fig. 21. Worm drives for rear axle transmissions are made in large quantities at the plant of the Timken-Detroit Axle Co. Of course, these worms and the worm-shaft bearings, etc., are carefully machined and precautions must be taken to prevent damage through one worm striking another. This is accomplished by the use of special trucks with "cradles" in which the worms are held without danger of damage

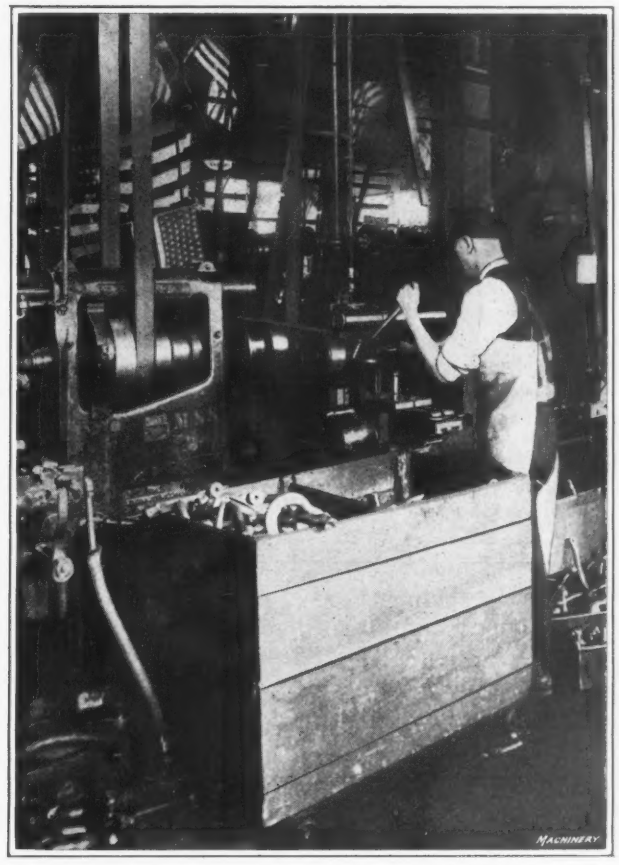


Fig. 22. Forgings, castings, etc., delivered to machines for a specified operation must be kept separate from those on which the operation has already been performed. One truck for blanks and one for machined work take up considerable space. A better method is to have one truck with a partition dividing the space into a compartment for blanks and a second compartment for finished work (Timken-Detroit Axle Co.)

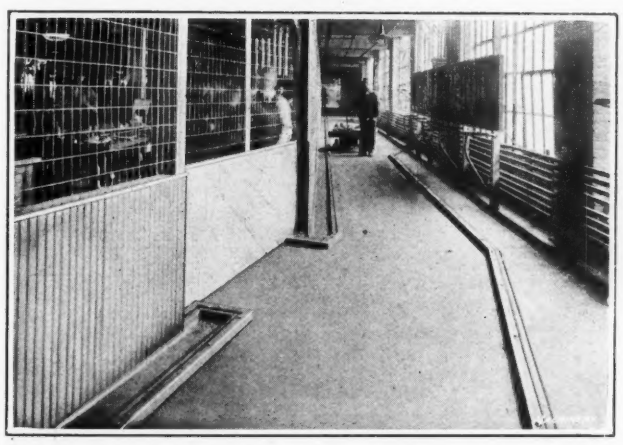


Fig. 23. In order for trucking to be done efficiently, it is of absolute importance that all aisles in the factory be kept open. Instead of a paint line down each side of the aisle, the Timken-Detroit Axle Co. uses 2- by 4-inch timbers protected with angle-irons. These effectually prevent trucks running out of the aisles

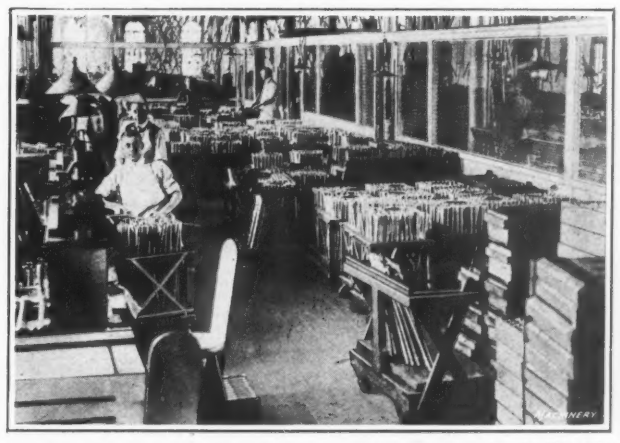


Fig. 24. In one of the United States government arsenals, 20,000 rifle barrels are inspected at one time. Obviously, this form of work calls for careful methods of handling. Not only is it necessary to provide means of transferring work to the inspection department, but the trucks must be so made that finished surfaces of the barrels will not be marred

TABLE 4. STANDARD SIZES OF CRANES SUITABLE FOR GENERAL SERVICE, WITH HOISTING AND TRAVELING SPEEDS[1]

Size in Tons of 2000 Lbs.	Standard Hoisting Speeds, Feet per Minute	Bridge Travel Speeds, Feet per Minute	Trolley Travel Speeds, Feet per Minute	Size of Aux. Hoist, Tons	Aux. Hoist Speeds, Feet per Minute
5	25– 60 30– 75 40–100	300–350 400–450	100–150		
10	20– 50 25– 60 30– 75	300–350 400–450	100–150	3	30– 75
15	17– 42 20– 50 24– 60	300–350 350–400	100–150	3 or 5	50–125 40–100
20	12– 30 15– 40 20– 50	250–300 300–350	100–150	3 or 5	50–125 40–100
25	10– 25 12– 30 16– 40	250–300 300–350	100–150	3 5 10	50–125 40–100 25– 60
30	10– 25 12– 30 14– 35	250–300 300–350	100–150	5 or 10	40–100 25– 60
40	9–22 10–25 12–30	250–300 300–350	100–150	5 or 10	40–100 25– 60
50	8–20 10–25 12–30	200–250 250–300	100–150	5 or 10	40–100 25– 60
60	8–20 10–25 12–30	200–250 250–300	100–150	10 or 15	25– 60 20– 50
75	6–15 8–20 10–25	200–250	100–150	15	20– 50
100	5–12 6–15 7½–18	200–250	100–150	20	20– 50
125	5–12 6–15	200–250	100–150	25	20– 50
150	5–12 6–15	200–250	100–150	25	20– 50

Machinery

[1] Practice of Pawling & Harnischfeger Co., Milwaukee, Wis., with Type A and Type C trolleys. Capacities can be doubled by using two standard trolleys on a single bridge.

out of equipment in a department, it is often possible to so locate a given jib crane that it provides for transferring work to several machines. For instance, in the plant of the Gisholt Machine Co., Madison, Wis., vertical turret lathes are so grouped that one jib crane carries work to and from five machines. Similarly, in the plant of the Griffin Wheel Co., Chicago, Ill., car-wheel molds are laid out on the foundry floor in a circle, at the center of which a jib crane is located. This crane takes a ladle of molten iron and swings it around into position over each mold so that the metal may be poured.

Portable elevators are used for somewhat the same classes of service as portable cranes, although the conditions under which they operate are rather different. Exceptionally good results may be obtained with portable elevators for such purposes as taking heavy dies out of storage racks and transferring them to drop-hammers or power presses, lifting heavy electric motors and countershafts into position to be bolted to their supports, raising barrels and boxes to the desired level to be rolled into freight cars or onto storage shelves, etc.

Freight elevators are used for lifting material from floor to floor in industrial plants. They may be of the familiar type in which material is carried onto the elevator by a truck or other means; or they may be of the self-loading type, *i. e.*, the load is placed on a platform so that it may be automatically taken off by bars which pass up between spaces in the loading platform and carry the work away.

Methods of Transporting Work

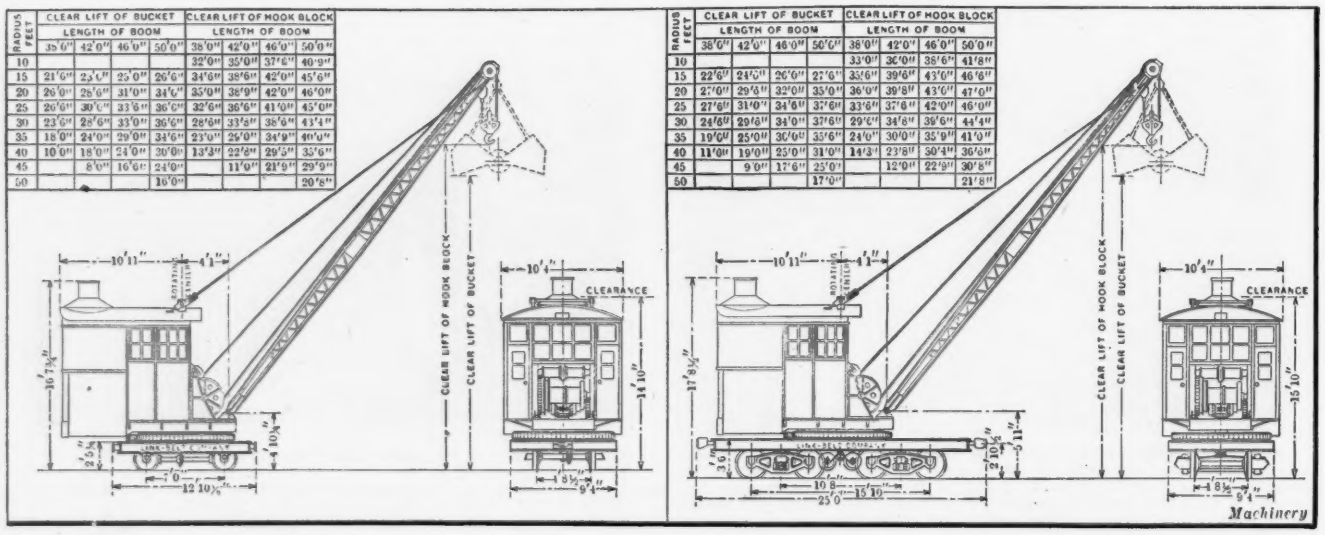
Of the ten forms of equipment for transporting material and product, there are four general classes of service that must be fulfilled, which are given in the following:

Hand-operated trucks or power trucks are used for the miscellaneous transfer of material from point to point in a factory, and their chief virtue lies in the fact that no fixed course

TABLE 5. CLEARANCE DIAGRAMS FOR STANDARD FOUR- AND EIGHT-WHEEL LOCOMOTIVE CRANES[1]

RADIUS FEET	CLEAR LIFT OF BUCKET, LENGTH OF BOOM 35'6"	42'0"	46'0"	50'0"	CLEAR LIFT OF HOOK BLOCK, LENGTH OF BOOM 35'0"	42'0"	46'0"	50'0"
10					32'0"	35'0"	37'6"	40'9"
15	21'6"	23'6"	25'0"	26'6"	34'6"	38'6"	42'0"	45'6"
20	26'0"	28'6"	31'0"	34'6"	35'0"	38'9"	42'0"	46'0"
25	26'6"	30'6"	33'6"	36'6"	32'6"	36'6"	41'0"	45'0"
30	23'6"	28'6"	33'0"	36'6"	28'6"	33'3"	38'6"	43'4"
35	18'0"	24'0"	29'0"	34'6"	23'0"	28'0"	34'9"	40'4"
40	10'0"	18'0"	24'0"	30'0"	13'3"	22'2"	29'5"	35'6"
45		8'0"	16'6"	24'0"		11'0"	21'9"	29'9"
50				16'0"				20'8"

RADIUS FEET	CLEAR LIFT OF BUCKET, LENGTH OF BOOM 38'0"	42'0"	46'0"	50'6"	CLEAR LIFT OF HOOK BLOCK, LENGTH OF BOOM 38'0"	42'0"	46'0"	50'0"
10					33'0"	36'0"	38'6"	41'8"
15	22'6"	24'0"	26'0"	27'6"	35'6"	39'6"	43'0"	46'8"
20	27'0"	29'6"	32'0"	35'0"	36'0"	39'8"	43'0"	47'0"
25	27'6"	31'0"	34'6"	37'6"	33'6"	37'6"	42'0"	46'0"
30	24'6"	29'6"	34'0"	37'6"	29'6"	34'8"	39'6"	44'4"
35	19'6"	25'0"	30'6"	35'6"	24'0"	30'0"	35'9"	41'0"
40	11'0"	19'0"	25'0"	31'0"	14'3"	23'8"	30'4"	36'4"
45		9'0"	17'6"	25'0"		12'0"	22'9"	30'8"
50				17'0"				21'8"



[1] Practice of Link-Belt Co., Chicago, Ill.

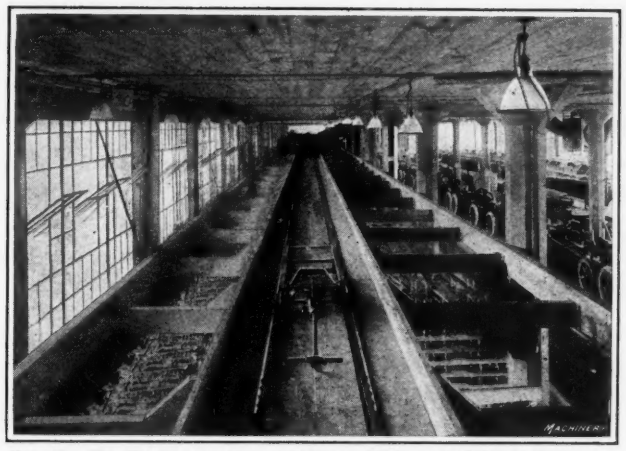


Fig. 25. The Palmer-Bee Co., of Detroit, Mich., installed conveyors and other equipment for handling work at the plant of the Paige-Detroit Motor Car Co. A rack was designed for storing automobile bodies, over which they are carried by a special elevating truck

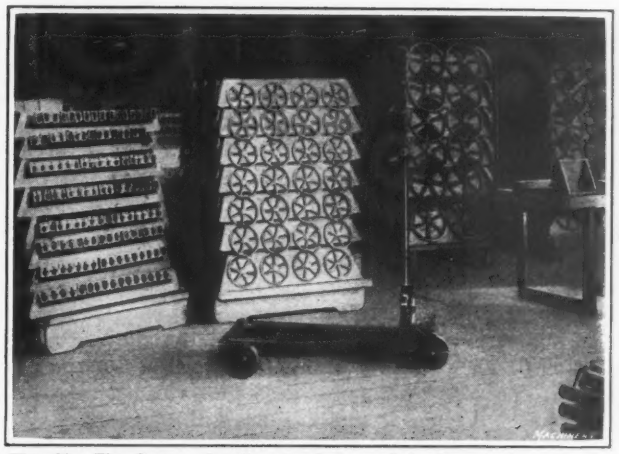


Fig. 26. The Cowan elevating truck is used in the plant of the De Laval Separator Co., Poughkeepsie, N. Y., for handling work. Platform racks hold finished parts and prevent them from striking each other. Note how racks overlap to provide clearance for work

Fig. 27. Telescopic boxes on platforms are used by the Pierce-Arrow Motor Car Co., Buffalo, N. Y., in connection with Cowan elevating trucks. Box sections are of standard size and can be built up as required. Note saving of floor space made possible

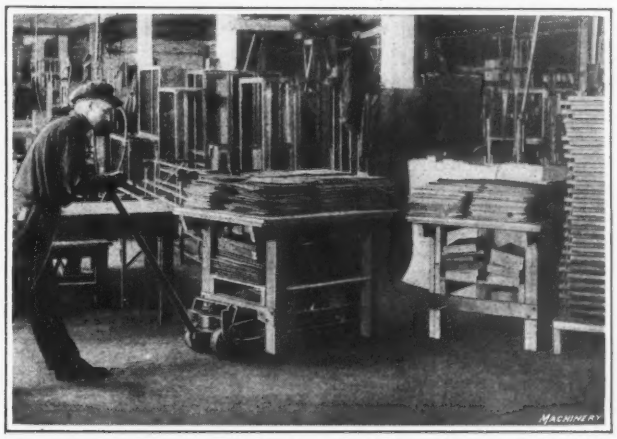


Fig. 28. It is often a good plan to make tables which can be handled on elevating trucks. This illustration shows a table loaded with work being handled on an elevating truck built by the Barrett-Cravens Co., Chicago, Ill.

Fig. 29. Where a number of cores have to be handled in a foundry, it is well to have racks for moving them. This illustration shows a power-driven elevating truck built by the Automatic Transportation Co., Buffalo, N. Y., carrying a rackful of cores to a baking oven

Fig. 30. Power-driven trucks handle loads at greater speed than is possible by hand. In the National Cash Register Co.'s factory, illustrated, where the output is large, power-driven trucks made by the General Vehicle Co., Long Island City, N. Y., are used in the shipping room

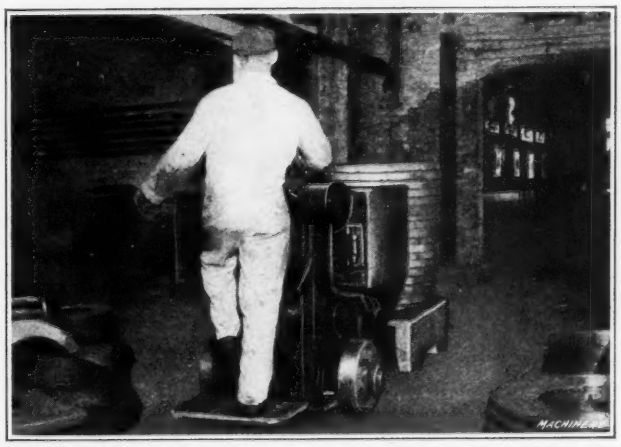


Fig. 31. For handling material of compact form, so that a full truck load can be stacked on a single platform, satisfactory results may be obtained by the use of power-driven elevating trucks. The additional speed of operation saves considerable time and labor

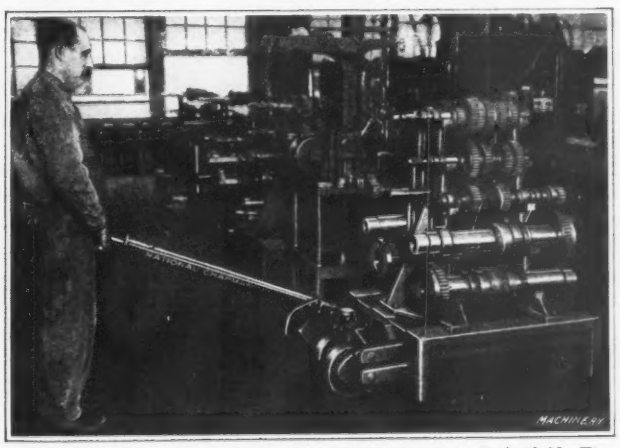


Fig. 32. In the Jones & Lamson Machine Co.'s shop, Springfield, Vt., a stand carrying all shafts, gears, etc., required for the headstock is loaded in the store-room and sent to the assembling department on elevating trucks built by the National Scale Co., Chicopee Falls, Mass.

need be followed. Hand-operated trucks of the plain or platform type may be either pushed or pulled, and when they are pushed it is desirable to have some form of buffer at the front to provide for opening swinging doors without delay. This buffer should be of a curved shape, so that if the truck gets into a jam, the buffer will assist in guiding the front through a narrow passage. A curved buffer also prevents damaging swinging doors in the shop, which are often pushed open by bumping the truck against them. For short hauls, hand-operated trucks are most satisfactory because of their lower cost and small upkeep charge; but in case heavy loads have to be hauled considerable distances, it is better to use power trucks, and these are ordinarily made of the storage battery type. In the plant of the Timken-Detroit Axle Co. and elsewhere, an alternative for power trucks is provided by having platform trucks arranged with couplings, so that they may be connected in trains and pulled by an "engine" which is equipped with the motor of a discarded Ford automobile. Such trains of cars are pulled from the forge shop to the first machine shop—a distance of about one-eighth mile—and enable material to be handled much more rapidly than it could be with hand-operated trucks.

Where it is desired to transfer work along a well defined route of no great width, use may be made of a track equipped with trolley hoists of the hand-operated type or furnished with electric or pneumatic motors. For the same class of service, use may be made of conveyor systems of various types, but as a general thing conveyors are not employed unless there is a large volume of work to be handled. Industrial railroads on which trains of cars are pulled by steam or electric engines are not commonly employed unless it is required to carry very heavy loads, and in order to be a paying proposition there should be enough work to be done to enable the industrial railroad to earn a satisfactory return upon a somewhat heavy investment.

Jib cranes are more properly used for lifting work and material, but in a limited sense they may be discussed under the heading of transportation, because cranes of this type are employed for swinging heavy loads a short distance between trucks and machine tools on which work is to be done, and for similar classes of service. Jib cranes may be equipped with hand-operated hoists or with electric, pneumatic or air hoists, the air cylinder type being one of the most common.

Locomotive cranes, although generally used for swinging a load through relatively short distances, are supported so that the load may be picked up and carried any desired distance. Some fairly small factories make good use of locomotive cranes, although at first thought it may appear as though they have not enough work to keep such an equipment busy. A locomotive crane, when not in use for the purpose of lifting, may be satisfactorily employed as a switch engine, and it is this "fill in" work that has led to a considerable increase in the application of this type of crane. A smaller form of crane combining the same general features of design as a locomotive crane is made with a swinging arm of relatively short reach, which is supported on an electric motor-driven truck.

The chief distinction between the classes of service for which some form of trolley system is suitable and those for which a traveling crane is required is that provision is made for carrying work along a definite course in the trolley systems, while an entire area may be served by cranes, as, for instance, the whole floor of a shop. Traveling cranes are of numerous types and may be equipped with electric or air motors; in addition, they may be hand-operated or of the one-, two or three-motor types, according to whether the hoist, trolley and trucks that support the bridge are motor-driven. There are two general types of equipment used for this purpose, *viz.*, the traveling crane supported on runways carried by the structure of the building, and the gantry crane on which the hoist and trolley are carried by a structure which runs on truck wheels carried by rails placed on the ground. The distinction in use between these equipments is that traveling cranes are used inside buildings, while gantry cranes are used in railroad yards and similar places out of doors. In such cases it will be found economical to build a structure to carry a traveling crane, if the probable saving in power will be sufficient to warrant such an expenditure. In operating a gantry crane, additional power is consumed in traversing the structure that supports the bridge, and if a lot of service is required of the crane, this increase in power consumption may more than offset the lower first cost of the gantry crane.

Handling Work of Assembling Department

In plants engaged in the manufacture of complete products, that is, in machining parts and assembling them ready for shipment to the user, there is probably no better method of handling than sending completed parts to what is generally known as the "finished stores" department, from which they are drawn on requisition by the assembling department as fast as they are required. The introduction of various profit-sharing plans in industrial plants has been extremely valuable through its tendency to unify the interests of employer and employe, as both classes benefit through any increase of production which is made possible. To facilitate the handling of materials and the performance of machining operations as far as possible, and to make a corresponding increase in the earnings of men and the profits of employers, most large manufacturing plants have established what are known as planning departments, which employ engineers whose duty it is to devise time- and labor-saving methods.

Much has been accomplished in this way, but there is probably no one step which has effected greater savings in the cost of production than the development of what is known as the progressive method of assembling. This was first employed in the assembling of parts to form complete motor cars, and as practiced in automobile factories, it consists of putting the automobile frame on a traveling conveyor which runs the entire length of the assembling shop. This conveyor carries the frame along, and stationed at intervals along the track are gangs of men who perform specified parts of the work of assembling. These men are kept constantly supplied with parts, which they put in place on each car as it passes their station; thus the conveyor constitutes a pacemaker which stimulates activity on the part of the men and keeps them working at top speed.

Practice varies in the method of handling progressive assembling in different automobile plants. In some cases the automobiles which are constantly getting nearer the completed condition are moved along the track by a power-driven conveyor, as previously mentioned, while in other cases each frame supported by the axles and wheels of the automobile is run along the track as fast as the different groups of men are through with their task. The former is usually the better method, as when the work is moved along by hand the personal equation becomes the determining factor in establishing rates of production, so that much of the possible benefit of the plan is lost.

An alternative method is employed in assembling automobiles in the plant of the Studebaker Corporation, Detroit, Mich. Under this plan the cars are all connected to a conveyor, which, instead of running continuously, is moved intermittently by a man who is stationed on a bridge at the head end of the track and operates control levers to move the cars forward one station as soon as the assembling operation has been completed by all the men along the track. Each station is given a number, and a push-button is provided by which a signal is sent to the man on the bridge that the work of assembling at that station has been completed. These signals consist of electric lights which glow as soon as the push-button is pressed and show the numbers of the stations that have completed their work.

When all the lights are on, the man on the bridge immediately throws over his control lever and advances the automobiles on the assembling track to the next station. This man keeps a record of the order in which assembling operations are completed at the different stations and the number of men at each station is regulated according to the complexity of the work, the idea being to have all of the assembling operations completed at the same time. Should it happen that a given station is conspicuously behind time, an investigation is made to find whether the men at this station are taking an unnecessary amount of time or whether conditions of the work justify such an increase in the time required for assembling.

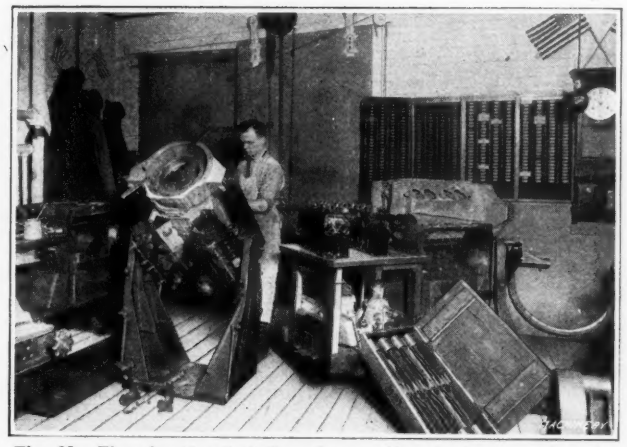


Fig. 33. Time is often lost through assemblers having to make trips to the store-room to obtain missing parts. The Cadillac Motor Car Co. has overcome this difficulty by constructing trucks with individual compartments for carrying a complete set of parts for a motor

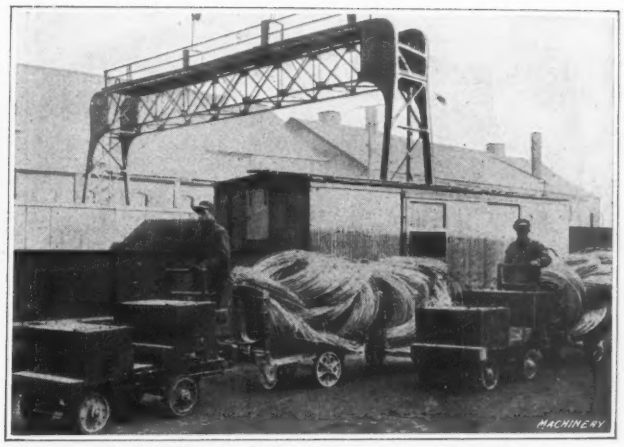


Fig. 34. Where material is bulky and requires considerable space on a truck, several trucks can be coupled together and pulled through the plant by a tractor. The illustration shows one of the mill type electric tractors built by the Automatic Transportation Co. pulling trucks

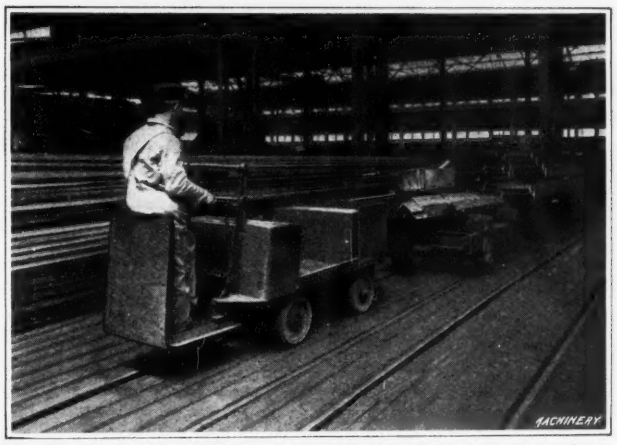


Fig. 35. In factories that have industrial railroad tracks trains need not always be pulled by an engine. Where the load is to be moved only a moderate distance, the cars can be pushed along with a motor-driven truck. An Automatic Transportation Co. tractor is shown in the illustration

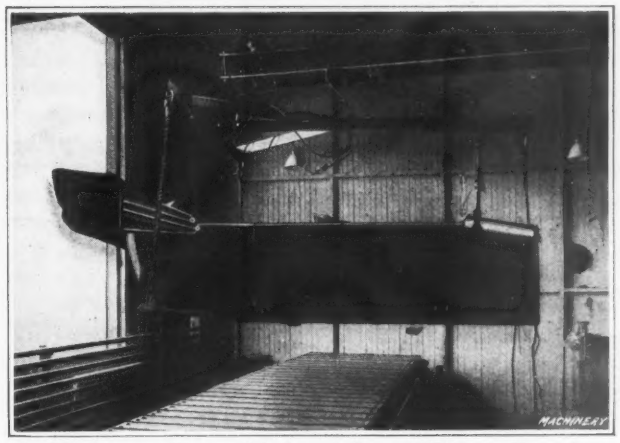


Fig. 36. In some cities municipal regulations prohibit extending a beam out over the roadway to support a trolley. The Palmer-Bee Co., of Detroit, Mich., made a movable trolley for the Paige-Detroit Motor Car Co., which can be run out over the road to pick up auto bodies

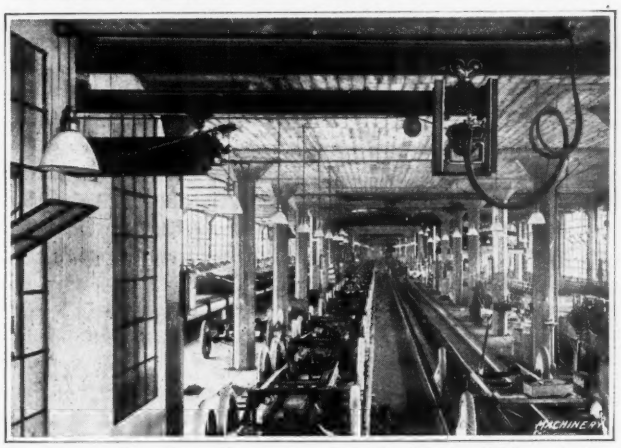


Fig. 37. In the trolley rail extension (Fig. 36), the air cylinder actuates the hoist and the pneumatic motor runs the extension out so that the hoist can pick up its load and carry it back into the shop, where the auto body is put on a conveyor and carried to the assembling department

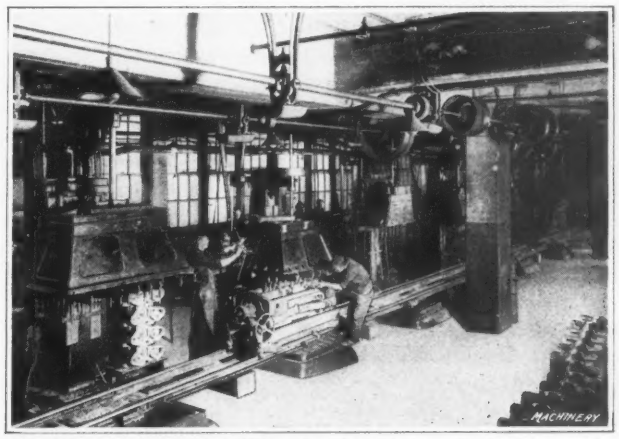


Fig. 38. At the Packard Motor Car Co.'s factory in Detroit, crankcases are drilled in jigs, which run on rails leading from machine to machine. These jigs are supported on trunnions and have index-pins to enable all surfaces to be brought into the drilling position

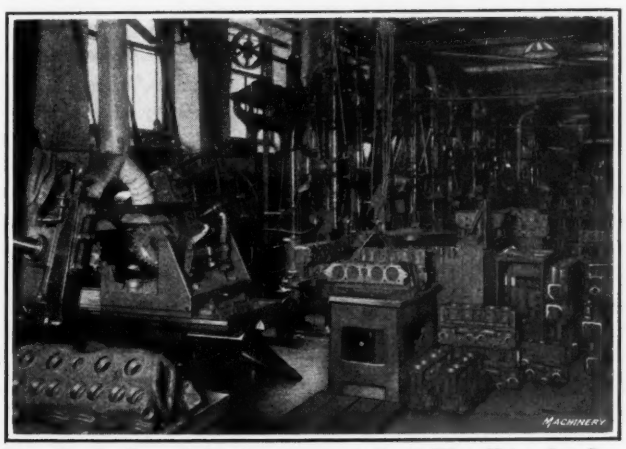


Fig. 39. In the cylinder department of the Cadillac Motor Car Co. there is a stand between each pair of machines, of the same height as the machine tables, so the operator does not have to stoop. Castings are swung from machine to stand and thence to next machine

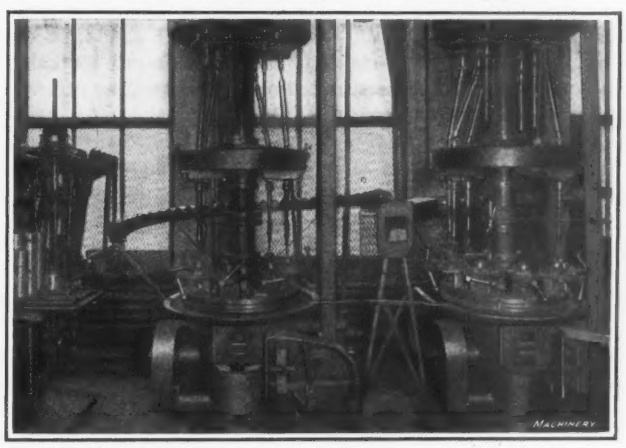


Fig. 40. In performing a sequence of operations on pistons, the Cadillac Motor Car Co. uses a trough in which the pistons are rolled from machine to machine. When an operation has been completed, the piston is removed from the machine and placed in the trough

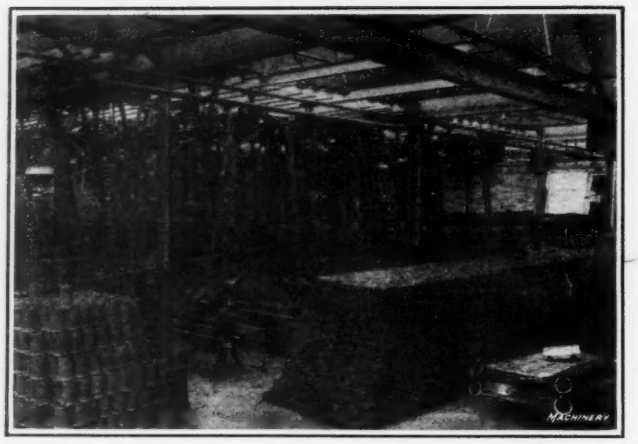


Fig. 41. Troughs are also used for carrying cylindrical work, such as pistons, from machine to machine in the plant of the Ford Motor Co. This illustration shows a somewhat different arrangement from that illustrated in the Cadillac factory. An idea of the enormous rate of production in the Ford shops will be gathered from the stack of pistons shown in the foreground of this illustration

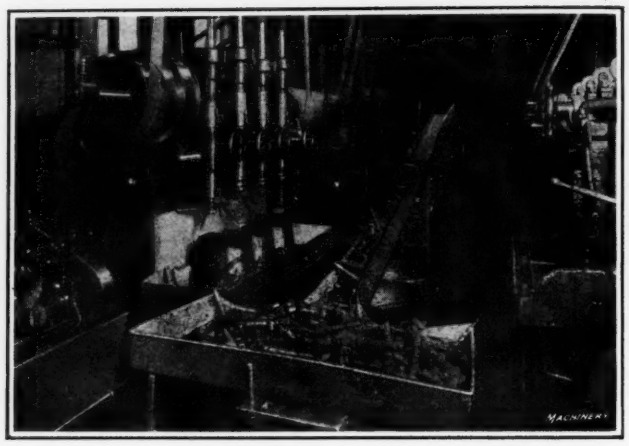


Fig. 42. In the Ford Motor Co.'s plant, application of work-carrying troughs is not limited to the handling of pieces of cylindrical form. Many small parts are carried in this way, but it is necessary to have a considerably greater pitch where the work must slide instead of roll in the trough. This idea is simple and could be used to excellent advantage in handling a great variety of work

Upon the result of this investigation a decision is reached either to supply one or more additional men to help with the work or to replace those men who are found to be taking too much time in the performance of their task.

Mention has already been made of the fact that the progressive method was developed for the assembling of complete automobiles, but its advantages have become so conspicuous that automobile manufacturers are now using it in many other kinds of work. For instance, motors, rear axles, clutches and many other parts are assembled by the progressive method, and illustrations showing the performance of this work are presented in this article.

The Palmer-Bee Co., Detroit, Mich., had installed a number of successful conveyor systems in the Packard factory, and suggested that it would be entirely feasible to apply the progressive method of assembling in handling the clutches. The result was that stands of the same type as those originally used, except that they are made lower on account of being supported on the conveyor, were placed on the power-driven conveyor, along which groups of men are stationed to perform the assembling operations. These men are constantly supplied with the parts they are required to put together, and as the conveyor sets the pace, the rate of production in handling this work has been greatly increased. Although progressive assembling was originally developed and is still generally used in automobile plants, the method is now finding application in other lines of work; in the second installment of this article illustrations will be shown of the progressive assembly of parts of gas ranges in the factory of the Detroit Stove Works, and of automobile cushion springs in the plant of the Detroit Wire Spring Co., Detroit, Mich.

Organization of Assembling Methods in Other Directions

Lack of organization in handling the work of the assembling department probably offers a better opportunity for unconscientious employes to waste time than is the case in any other department. This is due to the fact that in assembling, certain parts are likely to be missing, and this presents an opportunity for the assembler to go to the store-room for parts and take a lot of time in getting them. With the view of overcoming trouble from this cause, many manufacturers have organized their work of assembling in such a way that a complete set of parts for a given unit is carefully made up in the finished stores department and checked over to see that nothing is missing; this set of parts is then sent up to the assembling room and can be put together without delay. A case in point is seen in the motor assembling department of the Cadillac Motor Car Co., Detroit, Mich. This firm has refused to adopt the method of progressive assembly because its engineers hold the view that a forced rate of production must, of necessity, lead to turning out work which is likely to be found unsatisfactory in service. Every effort has been made to facilitate the work of assembling by keeping the men constantly supplied with the parts they need and by every other means that cannot exert a harmful effect upon the quality of the work produced. One important step in this direction consists of providing trucks that are furnished with trays divided up into compartments for all the parts of a motor. These trucks are sent empty to the finished stores department, where a complete set of parts for a motor is loaded into the truck. By having the trucks subdivided into trays and compartments, it is an easy matter for the men in the store-room to check up the parts to see that nothing is missing. Then when the truck goes up to the assembling room there is no chance of delay through lack of parts. Work is further facilitated by providing stands mounted on joints that permit the motor to be swiveled into any position that will be found most convenient for putting each part into place.

Application of Highly Systematized Methods of Automobile Factories in Machine Tool Work

The machine tool builder who is being shown through one of the large automobile factories is bound to be impressed by the results obtained from the highly systematized assembling methods employed in these plants. But he is likely to regard this merely as a case in which scientific management has produced gratifying results and fail to see the possibility of applying similar methods in his own shops. However, these methods are capable of wide application—after making suitable modifications to adapt them to existing conditions. It is the purpose of the present article to describe the way in which such highly systematized assembling methods were applied in the factory of the Jones & Lamson Machine Co., Springfield, Vt., and the conditions which led to their employment. Credit for the development of this plan is due to Ralph E. Flanders, general manager of the firm.

It is an axiom of factory administration that the greatest return will be obtained from labor by arranging working conditions in such a manner that the men will be required to move about the shop as little as possible. The method of assembling to be described is employed on all parts that go to make up the headstocks of Jones & Lamson flat turret lathes, including the shafts for the lathe headstocks. A study of the methods of assembling formerly employed in the factory revealed the fact that a large amount of time was spent by the men in going to the store-room for supplies, in delivering the work which they had completed to the next department, and in various wasteful ways which were fostered by the conditions existing in the shop.

With a view of overcoming these difficulties it was decided to develop a method which would provide for delivering the necessary parts to each man employed in the assembling department, so that he could carry on his work without the necessity of going to the stock-room. There are two obvious advantages in such a plan; the possible loss of parts is avoided and the time of the assembler is saved, as the delivery of parts from the stock-room can be looked after by a boy whose time is of little value. The assembling department was then laid out in such a way that the work would move in a continuous circuit and its transfer be simplified as far as possible.

Fig. 43. For handling pieces that are too heavy to slide in troughs, and where it is only required to transport the work a short distance, rails are set up in the Ford Motor Co.'s factory, along which the work can be slid from machine to machine. This saves lost production during late hours of the afternoon which would otherwise be caused by machine operators becoming unduly fatigued

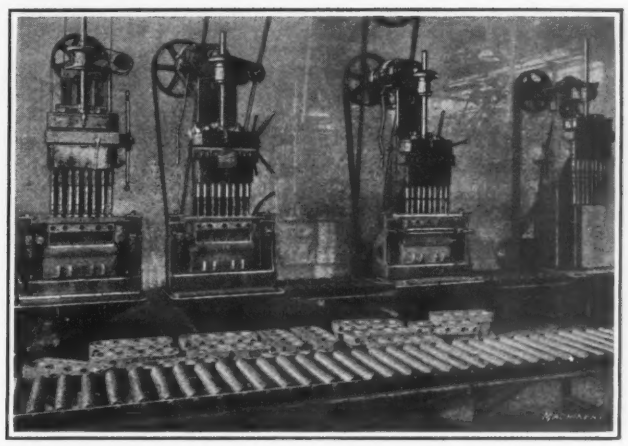


Fig. 44. Sometimes it is feasible to design jigs and fixtures in which work may be held for the performance of a number of machining operations. This illustration shows such jigs in use in the Maxwell Motor Co.'s shops in Detroit, Mich. The work and jig are pushed along from machine to machine on a roller conveyor, the operator following the jig right down the line of machines

In the department where the headstocks are assembled, each employe is assigned to a bench fitted with a vise, arbor press and the necessary tools. The parts are transferred from the stock-room to the assembling department in bins, each of which carries all the necessary gears and other parts required for one or more complete shafts or other unit assemblies. The bin in which these parts are contained is supported on a small truck carried on the stand, which is made so that it may be conveniently moved by an elevating truck. The truck carrying a bin full of supplies is backed up so that the tracks on the stand are in line with tracks located at the back of the assembling bench. The latch which holds the small truck in place on the stand is then released, and this "bench truck," as it is called, is then run onto the tracks on the bench and locked in place. At the time a bin full of parts is delivered to the assembling bench, a truck and empty bin is run off at the opposite end of the bench and returned to the stock-room, where it is filled with parts ready for delivery. Each bin full of parts is delivered from the stock-room against a signed order from the foreman of the assembling department.

Construction of Assembling Benches and Bench Trucks

The tracks for the bench trucks are located slightly below the working surface of the bench for the purpose of bringing the lowest compartments of the stock bins level with the bench and placing all compartments within easy reach of the operator. It will be evident that some provision must be made for securing each of the bench trucks in place. This is effected by latches which engage each side of a lug cast on the bottom of the truck body. When a truck is run into place on the bench or moved from one station to another, these latches are released by turning suitably arranged handles which cause the latches to drop to a horizontal position and release the lug on the truck.

The front corners of the bench are beveled off, the purpose being to enlarge the opening between adjacent benches so that it is an easy matter to back the elevating trucks into place. Cleats are provided on the floor at the end of each bench which engage the legs of the stands on which the bins are brought out from the stock-room, thus locating them in such a position that the tracks are in line with the tracks on the assembling bench. These stands are to be arranged with wheels so that the elevating truck can be dispensed with.

Taking Machine to Work

The idea of making it unnecessary for the workmen to leave their places in the factory has been carried a step further by providing portable drilling machines for use in the assembling department. The equipment consists of an "Avey" bench drilling machine, made by the Cincinnati Pulley Machinery Co., which is mounted on a stand used in connection with an elevating truck. It will be evident that the individual motor drive makes it possible to connect with the electric circuit in any part of the shop where the machine is to be used. The drilling machine is used for drilling pin-holes in the shafts at the time the assembling is done in order to get exactly the required relation between the different parts for the machines. It has been mentioned that the stands on which these drilling machines are mounted are so designed that an elevating truck may be used for moving the machine about the factory; but as in the case of the stands for the stock bins, it is intended to apply wheels so that the use of a truck will be unnecessary.

The method by which the parts are delivered from the stock-room has already been referred to, and there is little more to be said about the work of assembling the shafts beyond the fact that special stands are provided on which the complete shafts are stacked pending their delivery to the men who assemble them in the headstocks. On these stands brackets are provided for holding the shafts, the former being faced with soft brass to prevent scoring the bearings. Each rack has a capacity for holding the shafts required for two complete headstocks, and represents a normal day's work of one assembler. As the factory is at present turning out four single-spindle lathes a day, it will be obvious that it is necessary to have two men employed in assembling shafts. The output of these two men is passed along to the two head assemblers, where the bearing linings are fitted into the headstock castings and the shaft is assembled in place. Special assembling stands are used to support the work, and electric hoists are provided on each side of the assembling department to assist the men in lifting heavy parts. These hoists are arranged on I-beam trolleys which extend the whole length of the bay directly over the space in which the assembling stands and shaft racks are located, so that the hoists may be used if necessary at any bench. It should be noted, however, that they are in general use only at those benches where the headstock castings themselves are handled, inasmuch as every item of the equipment, with the exception of the assembling benches, is arranged to be moved by elevating trucks.

Criticisms of scientific management are often made on the grounds that the cost of installation is high, that it complicates the routine work of the factory, and that the benefits obtained do not justify the trouble and expense that have been involved. In some cases these contentions are undeniably true, but in the present instance it will be evident that the cost of installing the method was relatively low and the work of assembling has been greatly simplified rather than complicated. A concrete idea of the actual benefits resulting will be gathered from the fact that four men are now able to do the work for which ten were formerly required.

Importance of Advance Information

There are few apparently unimportant items of expense that are likely to assume more serious proportions than the wasting of time by men who are sent to stock-rooms to obtain materials and parts required in the assembly of machines and other manufactured products. In some shops where little system is followed, men regard a trip to the store-room as the equivalent of a half-hour's vacation. At the door they meet several acquaintances, and unless means are taken to check this form

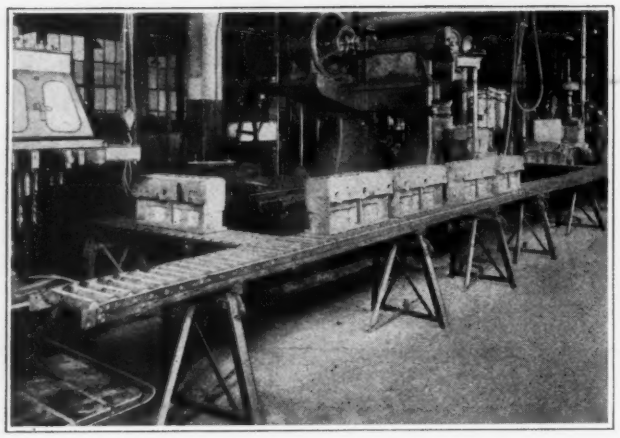


Fig. 45. The equipment shown in this illustration is somewhat similar to that illustrated in Fig. 44. A conveyor built by the Mathews Gravity Carrier Co., Elwood City, Pa., provides for easy transportation of work from machine to machine, but in this case the jig or fixture does not go with the work. Attention is called to branch lines running off to different machines

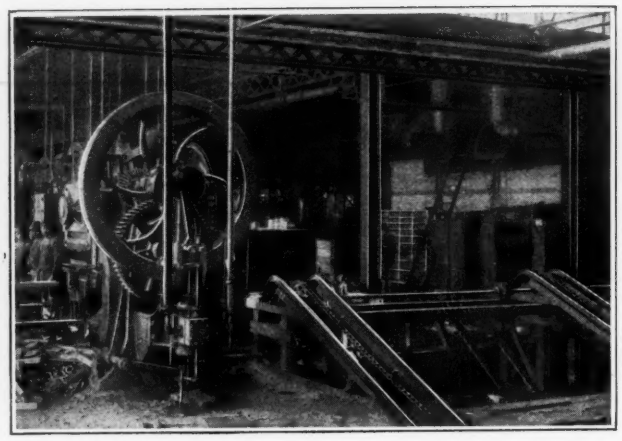


Fig. 46. A special conveyor is built by the Chain Belt Co., Milwaukee, Wis., for the rapid handling of bars in the Milwaukee works of the Illinois Steel Co. The chain conveyors carry the work up inclined rails, where it is in position to be fed into power shears, which are used for trimming the ends. Such an arrangement avoids handling the work by manual labor

of soldiering, there is likely to be a knot of workmen standing around the door of the store-room having a friendly chat. One of the reasons for the existence of such a condition is that men are often sent down to the store-room with a requisition slip calling for the parts or materials which are required, and as the attendant in the supply-room has a number of men to look after, each order must be attended to in turn. Such practice involves delay to the man who has handed in a requisition slip, and since a delay is more or less expected, even conscientious workers may unconsciously form the habit of wasting time when sent after supplies.

One way of overcoming this difficulty is to make a practice of having the foreman who sends for supplies telephone his order to the supply-room at the time he hands the requisition to the workman who is to be sent after the material. Such a practice involves little loss of time, and as the store-room attendant has received advance information of the requirements, he has had an opportunity to get the order assembled ready for immediate delivery to the messenger who hands him the foreman's signed requisition slip. In this way wasting time by both the messenger and the store-room attendant is avoided, because the attendant can utilize time when he would be otherwise unemployed in making up orders which have been telephoned him, and this avoids delay on the part of the messenger when he arrives at the store-room. Standard telephones may be used for this purpose or one of the automatic inter-department telephone systems may be employed to advantage. The "Select-o-phone" manufactured by the Screw Machine Products Corporation, Providence, R. I., is a suitable form of apparatus for this purpose. As it is the practice in many moderate sized shops to allow experienced mechanics drawing from forty to fifty cents an hour to go after supplies, it is important to adopt some method of preventing these men from wasting their time.

Assembling Machines with Bed Castings Bolted onto Elevating Truck Skids

In assembling machine tools and other machinery of moderate size, some manufacturers have found it advisable to bolt the bed casting down to an elevating truck skid as soon as the planing operations on the casting have been completed. After placing on the skid, it is an easy matter to move the casting around with an elevating truck, so that it may be carried to the inspection department and then be sent on to the assembling room where small parts are put in place. After assembling, the machine may be taken to the painting and shipping room and easily placed in a freight car. Elevating trucks are now so generally used that the chances are in favor of the purchaser of the machine having a truck which he can run under the skid and easily pull the machine out of the car and haul it to any desired position in the factory. Should it happen, however, that his plant is not equipped with elevating trucks, making it necessary to use the slow method of rolling the machine into place on rollers, the fact that the machine is mounted on a skid is a benefit rather than a drawback, because the skid forms a good smooth bearing for the rollers.

Taking Tools to Work

In handling heavy work, considerable time is often required for transferring the pieces to a machine and setting them up. Such a practice means a heavy expense both for labor and for equipment which must be provided for handling parts of this kind. In many cases this is unavoidable, but there are instances where much of the trouble can be overcome by the use of portable tools which are taken to the work instead of carrying the work to the machines. Drilling, reaming and grinding operations are often performed by portable tools driven by either electric or pneumatic motors, and such work as snagging castings, etc., is conveniently done by portable

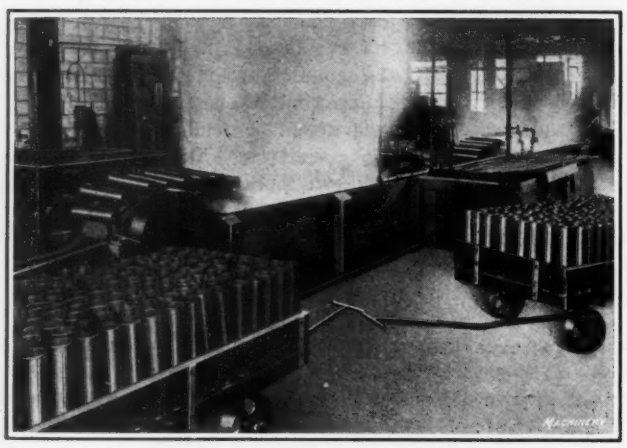


Fig. 47. For carrying work through a series of pickling and rinsing baths to remove grease, the Chain Belt Co. built the special conveyor system illustrated herewith. This is shown carrying brass cartridge cases through the pickling baths. The conveyor consists of two strands of this company's "Griplock" roller chain belt with cradles for supporting the cartridge cases

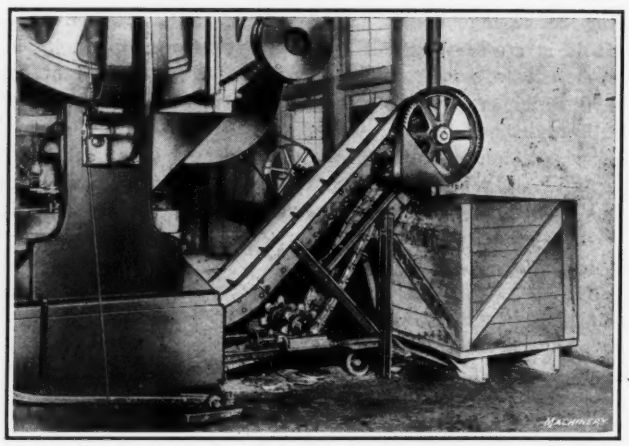


Fig. 48. Presses running on repetition work are often seriously slowed down to permit the operator to remove the work by hand. Here we show a special conveyor built by the Chain Belt Co. for handling product of a blanking press. Work is carried away by the conveyor and dropped into a box, which is hauled away on an elevating truck after it has been filled

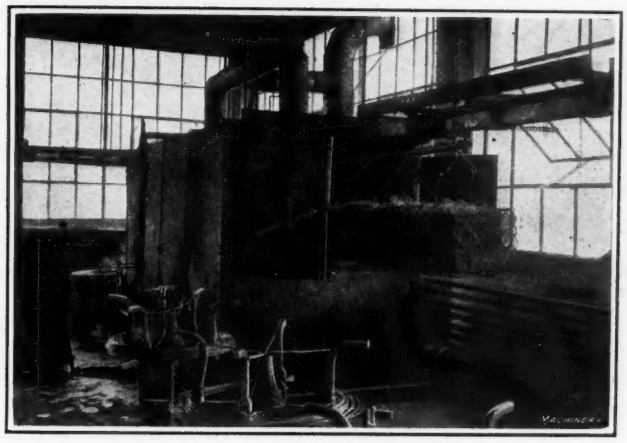


Fig. 49. Usually it will be found desirable to employ standard forms of elevating and transporting equipment whenever this is possible. In many cases standard equipments can be adapted for special conditions by the addition of auxiliary apparatus. A case in point is seen in this illustration, which shows baskets for carrying wire springs to a japan baking oven in the plant of the Detroit Wire Spring Co.

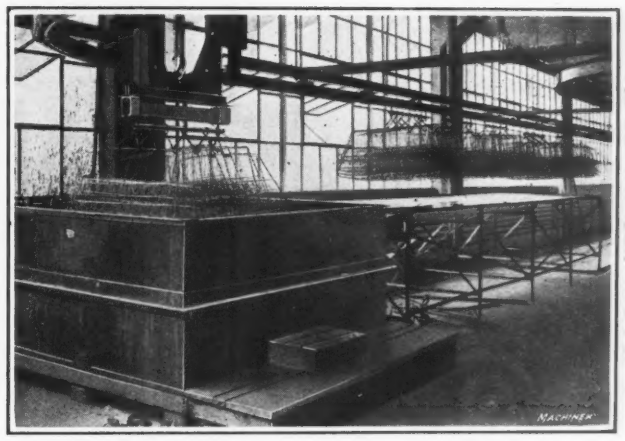


Fig. 50. To provide for dipping assembled cushion springs into a japanning tank, the Detroit Wire Spring Co. arranged a section of trolley rail on a hoist so that the trolley could be run onto this section of the rail to enable the work held by it to be immersed in the japan. After dipping, the rail is raised so that the trolley can run off onto the main line

chipping hammers driven by compressed air which actuates a reciprocating piston in a cylinder. Other examples of the obvious saving which may be effected through the use of portable tools are found in such operations as reboring locomotive cylinders. Here the saving is two-fold: not only is it unnecessary to take the work to a machine tool, but the expense incident to removing the cylinder from the engine and replacing it is also avoided, as the portable cylinder boring machine is so designed that it will operate with the cylinder in place on the engine. The only work required is to remove the cylinder head, piston and piston-rod, and replace them after the boring has been done. Other familiar examples of this kind are portable lathes and milling machines which are mounted on trucks so that they may be drawn about the works. Machines of this type are driven by electric motors, which make it an easy matter to form connection with a power circuit in the shop. In addition, there are portable turning, milling and keyseating machines which may be secured to a shaft or other cylindrical part in the position that it occupies in the shop, instead of requiring the shaft to be removed from its bearings and set up on the machine.

Use of Tote Boxes

There are a great variety of machine shop products that can be conveniently handled in tote boxes. Where the quantity of material to be passed along from machine to machine is small, it will usually be found satisfactory to handle single boxes by means of hooks; but where a large quantity of product has to be transferred, greater efficiency will result from handling a load of filled boxes on some form of shop truck. The New Britain Machine Co., New Britain, Conn., makes these tote boxes of steel, and they are designed in such a way that they may be stacked up to economize in floor space or to pile more boxes on a truck. The sides are folded over onto the ends, which are formed by the upturned extensions of the bottom; and the top edges of the stock at the sides and ends are turned over to form a hem, which precludes the possibility of injury to the operator. Near the corners where the strain is greatest, the stock is of quadruple thickness. A hole is punched in the handle for convenience in dragging with a hook, and the raised ends allow somewhat greater piling capacity in each box. Also the steel construction makes these boxes practically indestructible. Fig. B (first page) shows the use of these tote boxes in the plant of the New Departure Mfg. Co., Bristol, Conn., where they are used for carrying steel balls. The electric storage battery truck on which the load is being transferred is built by the Elwell-Parker Electric Co., Cleveland, Ohio.

Design of Auxiliary Equipment for Use in Connection with Elevating Trucks

Selection of a suitable type of auxiliary equipment for use in connection with elevating trucks will, of necessity, depend largely upon the nature of the work to be handled. Some classes of material may be stacked directly upon skids, while others will require some form of box or rack, this being particularly the case with large numbers of small castings, etc., which cannot be stacked up so that the different parts afford mutual support. Still another condition arises in the case of completely machined parts which must be held in racks to prevent finished surfaces from becoming bruised or marred. In some cases boxes are placed upon the familiar form of skids, while in other cases the boxes are constructed with skids on them. These boxes may be made of wood or sheet metal, according to the service required. In handling small parts that are delivered to a machine in large quantities, there is one requirement of considerable importance that is frequently overlooked. This is that the box should not be of

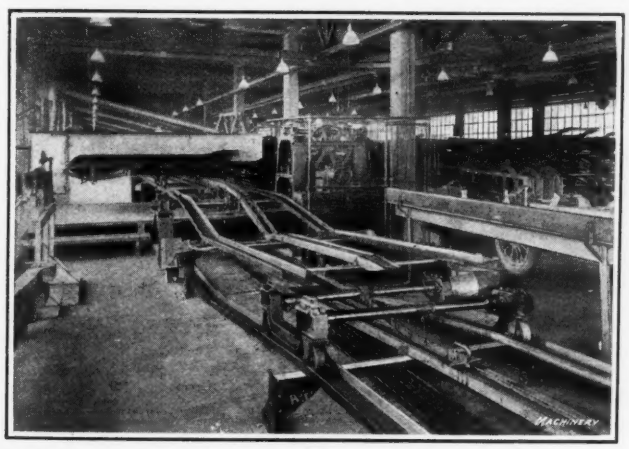


Fig. 51. Here we show a conveyor system installed by Palmer-Bee Co., of Detroit, Mich., for handling automobile frames in Paige-Detroit Motor Car Co.'s plant. Empty trucks return through tunnel and are caught by a hook on the conveyor. They run back over hinged section of track and receive frames from trolley system. One truck is coming up the incline, and another is on upper level of track with a frame on it

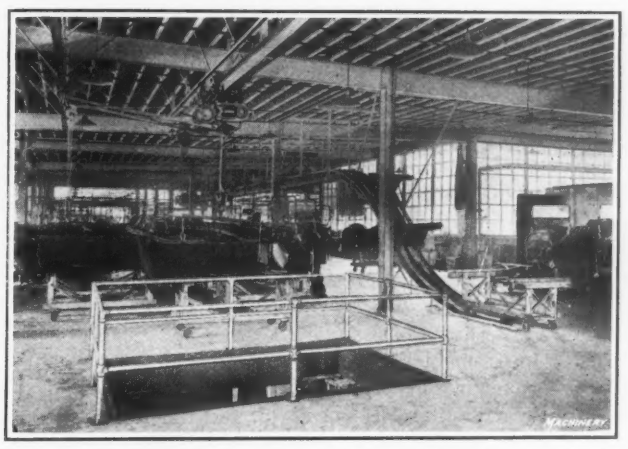


Fig. 52. Economy of space is a point of vital importance in plants handling a large volume of product. This illustration shows how automobile bodies are handled in the Willys-Overland Co.'s plant in Toledo, Ohio. The assembled bodies are picked up and carried away on a trolley hoist, and empty trucks are carried back to the beginning of the assembling line on the overhead track

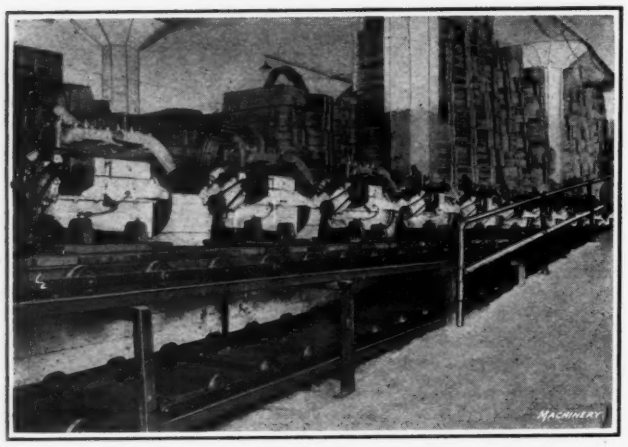


Fig. 53. The Willys-Overland Co. has a motor storage department on the opposite side of a roadway from the building containing the motor assembling department. Motors are carried over into this storage department on an apron-type conveyor which runs through a tunnel under the road. This conveyor was built and installed by the Link-Belt Co., of Chicago, Ill.

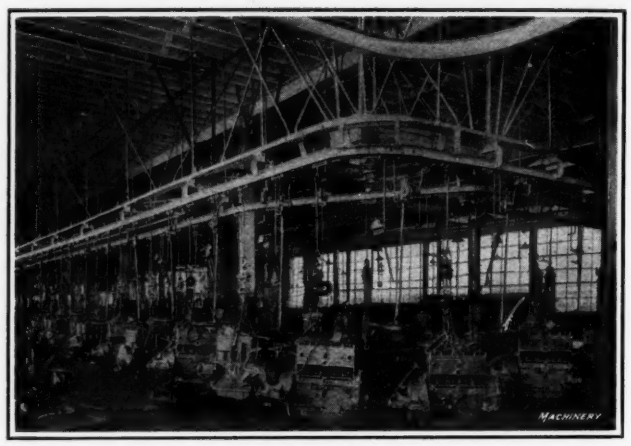


Fig. 54. In large plants, such as that of the Willys-Overland Co., a visitor is bound to be impressed by the variety of equipments employed for handling raw materials and product. For instance, the preceding illustration shows an apron-type conveyor for carrying assembled motors, and in this view the same class of work is being done by a trolley system installed by the Link-Belt Co.

such depth that, as the supply of work becomes exhausted, the operator has to dive head and shoulders into the box in order to reach pieces near the bottom.

In many plants a "false" bottom is put in the box at a height of about two feet from the floor. The box can still be made two feet deep, so that it has ample capacity, but when the supply is nearly exhausted the operator has no difficulty in taking out parts. Another good plan is to have boxes divided into two sections and delivered to machines with one of these sections full of parts upon which an operation is to be performed. As fast as each part is machined it is thrown into the other half of the box, and when all the parts have been taken care of they are sent on to the next department. Reference has just been made to the trouble that arises from having boxes made of such depth that it is difficult to remove pieces as the supply becomes exhausted. In the plant of the Packard Motor Car Co. this trouble has been overcome in another way. The boxes are made in sections which telescope together, so that, as the supply of parts becomes exhausted, the upper sections of the box may be lifted off, so that they do not hinder the operator in removing work. In this type of box also it is a good plan to have the bottom located at some distance from the floor, so that the operator does not have to stoop to reach his work.

Features that Add to Efficiency in Operation of Elevating Trucks

Arguments in favor of the use of elevating trucks are based on time studies that show that it takes four times as long to load and unload a truck as it does to move the load through an average length of haul in an industrial plant. With the elevating type of truck this loss of time is avoided, because machine operators are furnished with boxes adapted for use in connection with elevating trucks, so that raw material or finished product is taken from or placed on a carrier, on which it is hauled away by the truck. Another claim made for elevating trucks is that they often save time which would otherwise be lost in removing the load from a plain truck in order to release the truck for use in handling another load. Granting the accuracy of the claim that it takes four times as long to load or unload a truck as it does to move the load an average distance in a plant, it follows that each elevating truck saves the wages of four truckmen operating plain trucks. At this time, when labor is so scarce, the use of a truck that enables one man to do the work of five and save needless loading and unloading is especially desirable.

Usually from fifty to one hundred wooden platforms or boxes are used in connection with each truck, and these platforms or boxes are mounted on skids so that the truck may be pushed under them with the platform down, and the platform raised by pulling the truck handle forward, in order to lift the load from the floor so that it may be hauled through the shop. A lock on the lifting mechanism holds the load up, and when this lock is tripped with the foot-pedal, a check allows the load to descend slowly, so that there is no danger of damaging the load or causing trouble in other ways. In plants where floor space is at a premium, an important feature of these trucks is that when not in use the platforms may be stacked one on top of the other, and in this way they take up very little space, while in the case of plain trucks each truck occupies its full amount of space, no matter whether it is idle or in use.

The conditions under which elevating trucks are used will naturally vary considerably, according to the requirements of different industries. The following, however, is about typical of the efficient conditions of operation which are made possible through proper application of elevating trucks. At one side of a machine operator, within easy reach of his position at the front of the machine, an elevating truck sets down a platform, rack or box loaded with pieces on which a machining operation is to be performed. At the other side of the machine, also within easy reach of the operator, the truck places a similar empty carrier. It is then possible for the machine operator to take pieces from one container, perform the required machining operation, and deposit them in the container at the opposite side of the machine. When the latter is filled with finished pieces, the elevating truck carries it away to the next machine; and similarly, when the supply of pieces to be machined has been exhausted, a fresh lot is brought. In this way the non-productive time of the operator and machine is reduced to a minimum. In addition to handling materials and work in course of production, elevating trucks may be used to advantage in handling many other heavy loads, such as large dies, etc. In no case, however, can it be hoped to obtain maximum efficiency in the operation of these trucks unless a point is made of having them carry approximately their maximum load at each trip.

Special Electric Truck for Loading and Unloading Lumber

Investigations made by the Covel Mfg. Co., Benton Harbor, Mich., show that it costs between twenty and thirty cents per thousand board feet to handle lumber with a horse-drawn wagon. This company has developed what is known as the Ross electric lumber carrier, and with this truck it is claimed that the cost of handling lumber has been reduced to six cents per thousand feet. This estimate is based on operation of the trucks over a period of eighteen months. The Ross carrier runs over a load of lumber and picks it up by lifting two simple bolsters upon which the load is built, it being only necessary for the load to be kept within a certain height and width. The operator drives the machine over the load which is engaged by means of two hooks on each side that are lowered and raised by power from the motor. This can be accomplished in about ten seconds. The normal speed of the truck is eight miles an hour when carrying a full load, or about three times the speed of horse-drawn trucks.

The second and concluding installment of "Factory Transportation" will appear in the August number.—Editor.

METAL EXTRUSION[1]

BY F. G. SCHRANZ[2]

The art of extruding metal has been known approximately fifty years. About seventeen years ago, the American Brass Co. purchased the patent rights of Alexander Dick, an Englishman, who had made some experiments with extruding metal under high pressure and high temperatures. The first machines and extruding methods, compared with those of today, were crude and the operation was very slow. It was then the practice to heat the billet container during the extrusion process; a press with such a heating arrangement is shown in Fig. 1. In the later processes, annealing is unnecessary, as

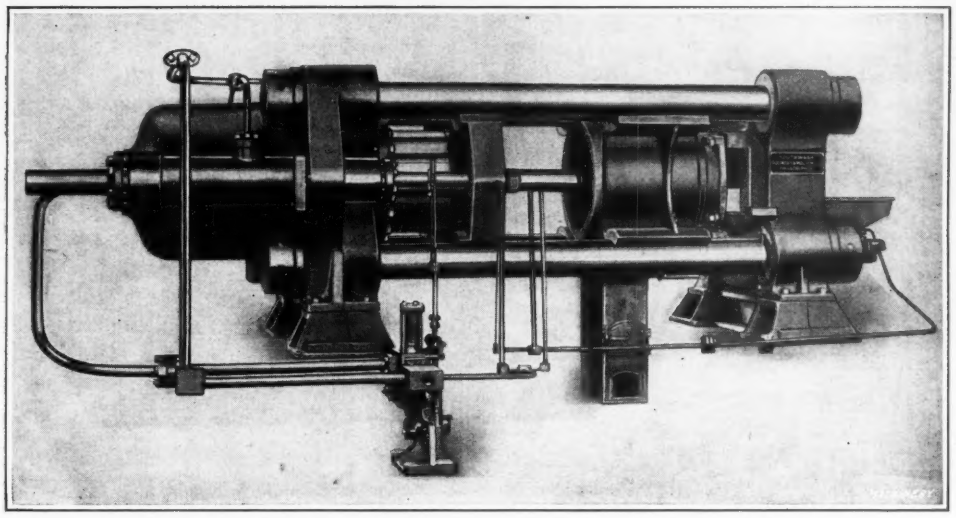


Fig. 1. Hydraulic Extrusion Press (1000 Tons Capacity) with Heater for Billet Container

the extrusion is completed in a single operation; pickling, also, is unnecessary except when a special finish is desired. Considerable trouble was experienced in getting material for the container cylinder and the extrusion ram that had sufficient tensile strength to withstand the exorbitant pressure required to extrude metal. Today, where a pressure of 100,000 pounds per square inch is exerted on the heated billet, only the best alloy steel is employed in the construction of the dies. In some presses, the dies are held in the head, which takes the pressure during the extruding process.

The extrusion machines generally used in this country are of the three- or four-rod horizontal type, with capacities of 1000, 1500, and 2000 tons, and a production of from 50,000 to 80,000 pounds of extruded rods daily. A 2000-ton press, like that shown in Fig. 2, has extruded sixty billets per hour. These billets were 8 inches in diameter, 30 inches long, weighed 450 pounds, and the production was 20,000 pounds of finished rods per hour. The entire machine is constructed of open-hearth steel castings. The pressure in the main cylinder is 6000 pounds per square inch. A special valve is used for distributing the high-pressure water to the main cylinder. In many cases, this press is operated from a high-pressure hydraulic pump only, but if an accumulator is employed the output can be increased considerably. A hydraulically operated shifter inserts the billet into the container, and quickly removes the die-holder after the thrust block is withdrawn, bringing the billet stump under a cutting-off shear.

One of the greatest difficulties encountered in machines of this type is the removal of metal waste remaining in the pressure chamber after the extrusion operation has been completed. Metal forced between the joints by the high pressure solidifies and becomes difficult to remove. In the Southwark press, at the end of the extrusion, an auxiliary cylinder operates the pressure chamber in the reverse direction, opening the space between the pressure chamber and the die so that the surplus metal can be easily removed from the top of the die. The pressure chamber moves on four guide rods between the head and the hydraulic cylinder. A tapered hole in the head end of the pressure chamber exactly fits the correspondingly tapered dies. This hole and the tapered end of the die form a close-fitting joint, which prevents the metal from being squeezed out between the two surfaces. The piston of the auxiliary cylinder is connected with the pressure chamber; at the beginning of the extrusion the auxiliary cylinder forces the pressure chamber against the die.

The billets are prepared in the brass foundry and contain from 55 to 63 per cent copper and not more than 3 per cent lead. This mixture is heated in crucibles which contain from 200 to 300 pounds of metal in pit furnaces that are fired with coke and anthracite, using natural draft. The molten mixture is turned into cast-iron cannon molds, which are supported vertically on trunnions at the center and provided with a metal plug on the bottom. The molds are generally dressed with a mixture of fish oil and powdered charcoal, before the metal is poured. In many cases, a mixing ladle that holds the contents of two or three crucibles is used. The billets shrink in cooling, and when the mold is tilted they easily fall out. They are then taken to a cutting-off machine where from 8 to 10 per cent of the length is cut off, thus removing any pipe or blow-holes from the top.

Before extruding, these billets are reheated to from 1500 to 1800 degrees F., depending on the copper content, in a continuous reheating furnace, the hearth of which is inclined 1½ inch per foot. If the billets are suddenly cooled, the surface of the metal loses plasticity and makes satisfactory work impossible, besides delaying the extrusion process. A cast-iron

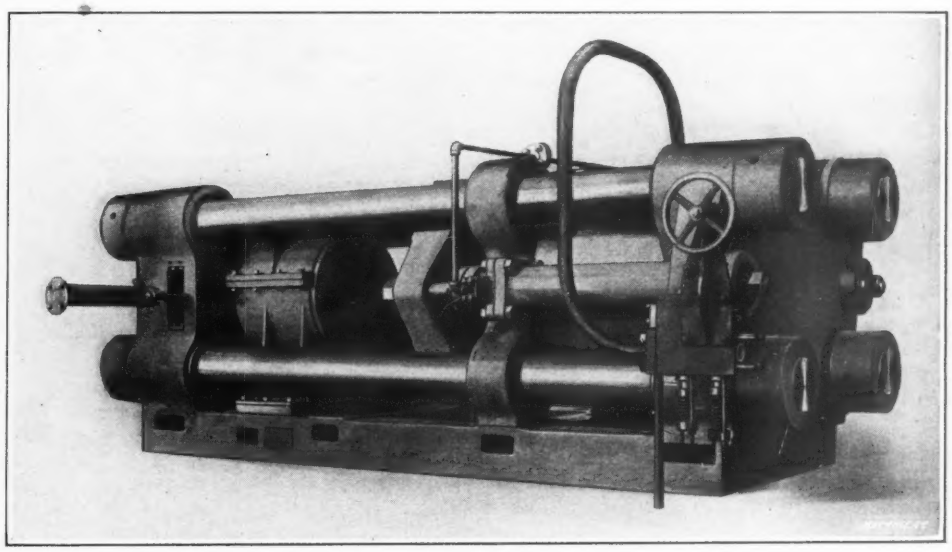


Fig. 2. Hydraulic Extrusion Press of 2000 Tons Capacity

table 50 feet long supports the extruded rods, and between this table and the back edge of the machine there is a 30-ton cutting-off press, which severs the ram stump of the billet from the die block. From seven to ten men are required for operating the extrusion-press equipment and furnace.

[1] See also MACHINERY, August, 1906, "Extruded Metal Sections;" October, 1911, "The Extrusion Process;" November, 1911, "The Extrusion of Shells and Tubes;" December, 1911, "Making Collapsible Tubes by the Extrusion Process;" June, 1912, "An Experiment in Extrusion;" July, 1912, "The Extrusion of Plastic Metals."

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FACTORY TRANSPORTATION

A study of manufacturing leads to the conclusion that the important factors of production are the workmen, the machines and tools provided for machining, the methods employed and the means installed for conveying work expeditiously from machine to machine, department to department, and thence to the assembling floor. The plant as a whole is most efficient when it functions like a machine, all its elements being coordinated to effect the desired end with the least internal friction and lost work. In an automatic machine the matter of holding the work and passing it on to the next work-holding fixture or bringing other tools into action must be carefully worked out on the drafting-board to the most minute detail. All its functions have to be planned before building the machine. But, unfortunately, it is not uncommon to find manufacturing concerns equipped with high-grade machine tools, housed in modern buildings provided with all sanitary conveniences, modern ventilating and heating systems and other modern features, yet without the means and methods of carrying the work through with a minimum of labor cost. And it should be borne in mind that the loss incurred by employing labor inefficiently in transporting materials is but a small part of the total loss caused by highly paid workmen being short of parts or hampered by piles of finished and unfinished work standing about their machines. The machine shop that is always in a congested condition because of inadequate work-handling trucks and other means of transporting parts is not only inefficient but dangerous to the workmen. Decreasing the congestion permits machines to be more closely grouped, and that may make unnecessary the addition of new buildings where now contemplated.

The manufacture of shells and similar munitions affords an excellent study of routing and transportation. The product is comparatively simple and lends itself to several means of movement; the large quantity produced has led to the development of unique methods, but the general principle of movement applies to all kinds of manufacturing. The volume of duplicate parts made and the need of producing them rapidly and at low cost have forced managers to recognize certain obvious principles of efficient manufacture.

The article in this number of MACHINERY on factory transportation is a review of existing methods of moving work from machine to machine and from one department to another, and was written with the object of pointing out the need of close coordination between the machining methods and the work-handling methods. The shop in which all these elements of production exist is one that should be capable of turning out a satisfactory product at the lowest cost.

* * *

BANISHING SECRECY

One beneficent result that may come out of the war is the breaking down of the reserve or secrecy that too often has been maintained in regard to methods and means of production, and securing greater cooperation among manufacturers in kindred lines. The Canadian manufacturers, under the influence of the Imperial Munitions Board and their patriotic ardor to serve their country, have thrown their plants open to all legitimately interested in the making of shells, guns, cartridges and other munitions. This has resulted in pooling data and information, so that each interested concern can draw therefrom to improve its practice. Each contributes in order that he may receive, and the beneficent results are so pronounced as to suggest the extension of the idea to all classes of industrial activity. More cooperative effort is needed instead of keener competition. Competition of a destructive nature is war; and this is no time for war within the nation itself. We must pool our resources and knowledge for the common good in order that all may benefit, and thus be able to present the strongest front to the common enemy.

* * *

MACHINISTS' APPRENTICESHIPS

Apprenticeships and the need of trained machinists has been written about until the subject is worn threadbare, but at the risk of discussing a stale subject we call the reader's attention again to the article in the February number dealing with the apprenticeship system in the plant of the Pratt & Whitney Co. It seems that Mr. Hanson has taken the bull by the horns and developed a system for the express purpose of training young men to be machinists. Mr. Hanson holds that the trade of a machinist is an honorable occupation. He points out that all the leaders in the Pratt & Whitney organization were machinists to begin with, and that the very nature of the business requires that the leaders shall have had first-class mechanical training. Hence, while the avowed purpose of the apprenticeship system is to train men to be machinists, they are shown that if they cultivate intelligence, industry and research they may aspire to higher positions in the company's organization.

The fault with apprenticeship systems in many plants is that they were wrongly conceived and are poorly carried out. The education bestowed on the apprentices tended to make them something else besides machinists. Another trouble with apprenticeship systems in general is that the employers have not dealt honestly with their young men, nor have the young men been fair and honest with their employers. We believe that if a concern gains a reputation for dealing fairly and generously with its apprentices, much of the trouble experienced by young men leaving before their indentures are completed will be avoided. Apprenticeships should not be conducted for the purpose of training men to be virtually machine operators working at low pay. Apprenticeship instruction properly carried out is expensive, and the concern should not attempt to make the young man pay all the cost. It is better to be liberal in the matter of wage payments and secure the loyal service of the apprentices rather than to save a small percentage of their wages and lose them in the second or third year.

American manufacturers are beginning to realize something of the appalling cost of hiring and firing employes. A loyal, efficient organization is above price and one of the surest ways of creating an organization that will work for the common interest is to train young men in the elements of the trades and to pay them as much as they can obtain in other plants. They should be worth more to the employer who has trained them than to anyone else.

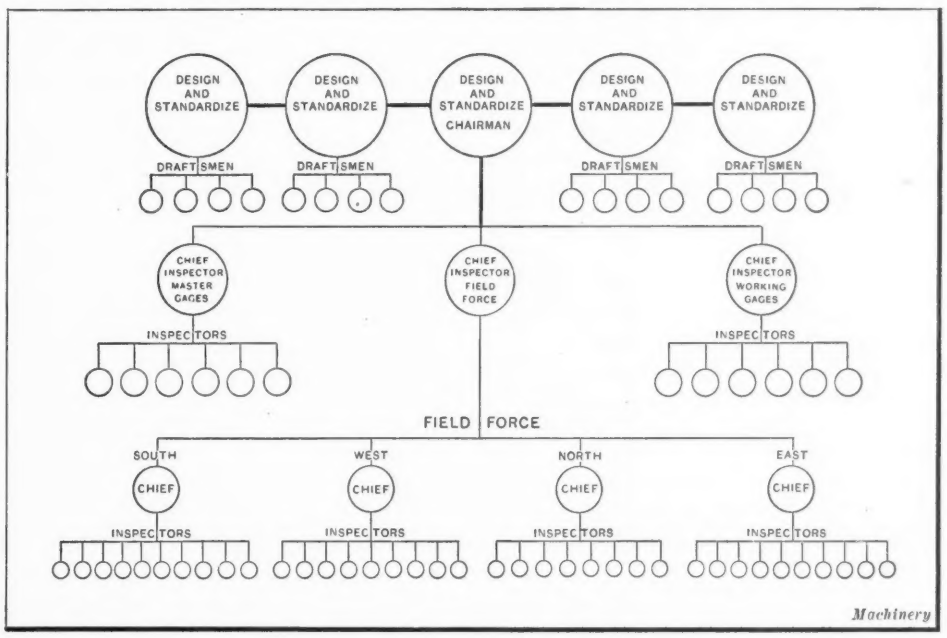
NATIONAL SUPERVISION OF GAGES

BY WILLIAM T. ILER, JR.[1]

There are many lessons in the standardization of munition manufacture that the heads of the Federal government may learn from the experiences of the American shops manufacturing tools and gages for our allies. When a Canadian shop obtains a contract for munitions, it receives from the Imperial Munitions Board a set of blueprints of the parts to be made and of the master gages. If the men in charge of the shop taking the contract know their business, they immediately organize a first-class tool-room, in which are made all the flat and simple gages. The thread gages and the more complicated gages are made in the United States, as the manufacture of these requires an experienced organization and expert men.

The Imperial Munitions Board requires each firm making munitions to send it two sets of master gages. These gages are inspected and, if passed, one set is retained by the board for the use of its inspectors and the other set is used as master gages by the manufacturer. The munitions manufacturer then has as many sets of working gages made as he deems necessary to take care of the inspection of the daily product.

In every contract that the Imperial Munitions Board makes with munitions manufacturers there is a clause that demands a predetermined daily production, and for each day that this production is not reached, a total equal to the predetermined daily production is subtracted from the total of the contract. This clause puts a premium on knowing what to do and how to do it in the least possible time. One of the largest and most successful munitions manufacturers in Canada realized the great importance of gages from the beginning; it therefore secured the best man possible for the head of its inspection department, paying him as large a salary as it paid the president of the company.



Proposed Gage Department of U. S. Munitions Board

Another Canadian company that had taken an order for 750,000 80MK-VII fuses, the delivery of which was to begin in two weeks from the receipt of the order at the rate of 1500 fuses a day, did not establish a tool-room or hire a toolmaker; but it ordered from an American company two sets of master gages and six sets of working gages, specifying that all these were to be delivered in two weeks from receipt of order. As each set comprised seventy gages, some of which took 200 hours to make, this company was immediately notified that deliveries could not be made as called for on the order, so it asked the gage-making company to do the best that it could. By working overtime and Sundays, the latter was able to deliver about one-half the gages in the first two weeks. These gages were sent by the Canadian firm to the Imperial Munitions Board, as it had no facilities for checking the working gages. The Imperial Munitions Board passed all the master gages with the exception of the graduation gages, which checked correctly on the first and last graduation but were out about forty seconds at the center graduation; forty seconds on this size gage is about one-half a hair breadth. These rejected gages were returned to the American company for correction. To make them right, it was necessary to attach a special indexing plate to a dividing head that was used on a very accurate milling machine. The difficulty of making these gages will be appreciated from the statement of the chief inspector of the Imperial Munitions Board that these were the first American graduation gages that had been passed.

When, however, the Imperial Munitions Board returned to the Canadian manufacturer the working gages, the trouble began. According to its custom, the gage company had made all working plug gages to the maximum limits and all working ring gages to the minimum limits. The tolerances on the parts of the fuse to be gaged were given on the official Munitions Board blueprint as $\pm$ 0.0003 inch; the blueprints of the master gages did not give any tolerance, so they were made within $\pm$ 0.0001 inch. The Imperial Munitions Board had attached to each working gage a tag on which was written the dimensions of the gage. On receipt of the working gages from the Imperial Munitions Board the Canadian firm immediately wired the American company that it had rejected all the working gages, as the plug gages differed + 0.0002 to + 0.00025 inch and the ring gages were — 0.0002 inch from the blueprints. Other sets were then made to the exact dimensions, which were accepted by the manufacturer. The folly of his method was forcibly brought to the manufacturer's attention shortly afterward, by the government rejecting 90,000 fuses. The gage company, however, did not lose anything, as it shipped the gages to another manufacturer, whose inspector said they were the best working gages that he had received.

The story of the Russian shells made in this country that were filled with sawdust and brickdust and accepted by the Russian government is well known. A story on a par with this is the experience of an American manufacturer who made fuse parts for a Canadian firm. This company could only see the profits and thought the less it spent for gages the greater would be its profits; so it purchased its thread gages, both plug and ring, from the lowest bidder and did not inspect them before using them on the work. The company was disagreeably surprised when the Canadian firm rejected its entire first shipment. The blueprints were immediately checked, and as these proved right, the gages were sent to a well-known gage-making firm for inspection. A short examination showed that they had been cut with a collapsible tap and die. The cost to the manufacturer of these so-called "gages," when the spoiled parts were taken into consideration, was many times the amount asked by the highest bidder.

In the fall of 1915, a foreign government gave a contract for fuses to an American watch-making company which was ideally equipped and organized for interchangeable manufacturing. The government supplied the manufacturer with a set of master gages it had O.K.'d, but sent no blueprints of either the fuse or gages. The master gages were given to a gage-making company with a request to duplicate them. By the time the gages were completed, the watch manufacturer received an official blueprint of the fuse and found that the master gages the gage company had delivered did not check up with the blueprint. As the makers claimed that the master gages were

[1]Address: 90 W. 164th St., New York City.

duplicates of the set furnished by the government, the original set was checked and found to be 0.0005 to 0.0025 inch off, so the government promptly paid for the gages.

The foregoing are only a few examples of the various difficulties that confront the munitions manufacturers as well as the tool- and gage-makers. The Federal government can avoid most of the errors made by our allies if it will follow a plan based on that of the Canadian Imperial Munitions Board.

Graphic Organization Chart

A condensed organization chart is shown herewith that, if followed, will accelerate the manufacture of munitions considerably. First, five men should be appointed to design and standardize the master and working gages. For this purpose they should have a well-equipped drafting department, which should prepare sets of blueprints of all gages and make all changes and keep the manufacturers informed of these changes. These men should be practical toolmakers who have risen to executive positions. They can be obtained by asking the large munitions manufacturers and tool- and gage-making shops to recommend, from their organization, a man who is qualified to hold this position. If followed, this will result in the nomination of probably thirty-five to fifty men.

This board should also have three inspection departments, one of which should pass on all master gages. Each company manufacturing munitions should be required to submit two sets of master gages for approval. One of these sets will later be used as the shop's masters and the other by the board's resident inspector. Another department should inspect all the working gages, because of the scarcity of toolmakers, which would make it impossible for the munitions manufacturer to establish a complete tool-room or inspect the gages rapidly and correctly; also, because of the scarcity of testing apparatus, such as micrometers, test blocks, height gages, sine bars, etc., that are absolutely correct, that is, not more than 0.00005 inch out.

It might be advisable here to caution all munitions manufacturers to test all micrometers, sine bars, test blocks, etc., before using them, as the writer has found that the only good instruments are those that were made before the war. Out of ten sine bars ordered from a firm that, before the war, had a reputation for very fine work, all but one had to be rejected, as they were out at least 0.0003 inch in each case. The manufacturers said that they could not guarantee their product with greater accuracy than $\pm$ 0.0005 inch, whereas before the war their guarantee covered an accuracy of $\pm$ 0.0001 inch.

This munitions board should also have a force of inspectors who would be stationed at the various plants making munitions. It should be the duty of these men to inspect all the finished product as well as to check working gages. These gages should be inspected for wear three times a week, and the final inspection gages at least twice a week. The inspector should also report each week the condition of the gages used in the shop and recommend the renewal of any or all of them. He should have the power to stop any operation if the gages are not up to size. All these inspectors should be practical toolmakers or men having had long experience in gages and their use.

The chart does not show a complete organization by any means, but will serve as a foundation for a highly efficient force that will lift about one-half the burden from the munitions manufacturer's back.

* * *

GROUP INSURANCE

BY J. D. WHITNEY[1]

Group insurance, a development of recent years, is based on the fact that large groups of people can be insured without medical examination and at a much lower cost. The reason that the medical examination can be dispensed with is that group insurance is applied simply to workmen already in the employ of men who have presumably chosen them because they are in good health and a good state of mind. The insurance company assumes that a factory owner, for instance, will not hire a man to do hard work in his factory if that man is on the point of death. It is claimed by manufacturers that it costs from $50 to $100 to break in a new man, and naturally an employer is not willing to make that expenditure on a man who is likely to drop off within a few months.

The reason that group insurance can be written at a reduced rate is that it is wholesale in its nature, and the insurance company saves a great deal on commissions and overhead expenses. The cost of group insurance is indeed so low that most employers find themselves able to pay the entire premium, though in some cases the employers feel that the men will be more interested in the insurance if they are required to contribute part of the premium. One progressive machine tool concern allows each employe to decide whether he will take a low-cost life policy at a minimum cost or a form of policy that will require more thrift and self-denial. But employers are encouraged to adopt the plan of paying the entire premium for the men, as the effect on the men is remarkable. Many business men claim that they get their money back in increased efficiency and loyalty in their employes.

Of the many hundred group risks, ranging from one hundred employes, which is the minimum, up to many thousands, that have been written by one company in the five years in which group insurance has been extensively cultivated, only one group contract has been discontinued, and that one for temporary reasons. This is in spite of the fact that group insurance is written on the one-year term plan and can be easily dropped at every anniversary.

Group insurance can be written on a great many plans. Indeed, a plan may be adapted to any particular case, but, generally speaking, the idea is this: After an employe has been with a concern for three or six months, or whatever length of time the employer thinks necessary to establish the presumption that the workman is going to stay, the workman receives a policy of insurance of a sufficient face value to enable his family to take care of itself for a period, in case the workman loses his life or is disabled. Some concerns provide $500, some $1000 or more, and some give each workman a policy valued at the amount of his annual salary. The most common kind of policy is life insurance with a disability clause, but health and accident insurance are also written on the group plan.

Among the companies that have taken out group insurance are many concerns that have always taken a paternal interest in their employes, and have been spending several thousand dollars a year providing burials for pensioners and taking care of their families for a few months, at least, after the death of their bread winner. These concerns have been glad to substitute the group plan and rid themselves entirely of the responsibility of taking care of dependent families. The general satisfaction of the workmen at being given their own resources in this respect is noticeable, and wherever the intelligence of the workmen is sufficiently high to enable them to comprehend the idea fully, the men receive the group plan with the utmost enthusiasm. It has decided advantages over the giving of bonuses at Christmas or on other occasions.

One of the earliest purchasers of group insurance was a large manufacturing concern in Michigan. When the plan was announced, a number of employes took a belligerent attitude and declared that they would not have anything to do with the scheme and would not even accept their certificates (each workman is provided with an individual certificate). Nevertheless, the company placed the insurance on all its workmen alike. The first one to die was the ring leader of the belligerent element. The wife was left without money enough to pay the funeral expenses and was in despair until somebody told her that $1200 was coming to her from the insurance company. Not long afterward the belligerents marched to the office in a body and asked for their certificates.

The New York legislature thought so well of group insurance, at its 1916 session, that it took group insurance out from under the limitation which it imposes on life insurance companies as to the amount of business they are allowed to write. Group insurance, of course, runs into the millions rapidly. There is about a quarter of a billion dollars worth of it in effect in this country at present, but the surface has not been more than scratched.

[1] Publicity Manager, Travelers Insurance Co., Hartford, Conn.

SNAPSHOTS ON THE ROAD

HOW MACHINE TOOLS ARE SOMETIMES BOUGHT—ONE WAY TO GET A MACHINIST'S JOB—HOW STEVE OILED THE PULLEYS—WHEN GOOD STEEL WAS POOR STEEL—MAKING THE SCRAP PILE PAY—COURTEOUS TREATMENT OF TRAVELING MEN—MACHINERY FOR THE SWEAT-SHOP

BY THE FIELD EDITORS

"—it was found to stick as close to the plane as though it were glued there"

THE pure theorist will ever be the laughing stock of the so-called "practical" man, but here is a case where both of them were fooled. It happened in a New England shop, where the elderly proprietor was a theorist and a young toolmaker the practical man. Mr. Theorist came in to George, the toolmaker, one day and with a burst of enthusiasm said:

"Look here, George, I want you to drop that job you're on and make a file-testing apparatus for me. I've just been down through the shop where all those kids are filing, and I find any number of files lying around which they claim are worn out. Now what I want is a device for measuring accurately how much these files are actually worn. You see, it's a simple matter; all we need is a tilting, graduated, inclined plane, made of cast iron, finished to a specified degree of smoothness. We will determine the angle at which a new file of any coarseness will slide down the incline and the angle at which a used file must slide to be considered worn out. You see, for a new No. 1 it might be 45 degrees, while the angle for the used No. 1 might be 28 degrees. Now, George, get right to work on this, and make it right, because it's an instrument of precision and there is no doubt in the world about the underlying principle."

George set to work and, according to the sketch furnished him by the boss, turned out, in a little less than a week, a specimen of his handiwork that was a joy to look upon, accurately graduated, and in every sense an instrument of precision. The boss was highly elated over the appearance of his pet device, and as the time approached for giving it the initial test, his enthusiasm grew. The first thing he did was to determine the sliding angle of a new file of a certain coarseness, which was found to be in the vicinity of 38 degrees. But when he came to try the same file very much worn, it was found to stick as close to the plane as though it were glued there, although tilted at the same angle.

This was a complete reversal of his calculations. Further experiment proved conclusively that the more the file was worn, the less tendency there was for it to slide. After close examination of the worn files, and a long consultation, in which George, the practical man, participated freely, the real cause was arrived at. It was found that a so-called "worn" file was indeed worn smooth on a large part of its surface, but at the heel and point a few scattered teeth protruded. These few teeth, of course, prevented the file from sliding much more than a whole bank of sharp teeth.

Mr. Theorist was sick at heart, not so much because of the failure of his theory, but because of the expenditure tied up in the file tester. George came to his rescue, however, by suggesting that it could easily be converted into an adjustable angle-plate such as he had been wanting for several years. Perhaps George had this in mind when he was making it, which may account for the accuracy with which it was made.

"A watchman saw me jumping the fence and came after me, which simply made me move faster"

How Machine Tools are Sometimes Bought

We often run into men who want to buy machine tools. In nine cases out of ten, they know just what they want and the buying is done intelligently, based on sound, practical experience, but occasionally, and especially during these busy times, machine tools are bought with a woeful lack of mechanical knowledge. For instance, a newcomer in the machine business, fresh from an exporting office, was asking us for advice on what kind of milling machine he should purchase for one of his clients. He wasn't sure whether he wanted a universal, plain or special manufacturing machine, but, as he expressed himself, "You will probably know what kind of machine my customer wants, because he has to mill all sorts of curious shaped pieces."

And he went away disgusted because we could not recommend exactly the type of machine best suited for milling "curious shaped pieces."

One Way to get a Machinist's Job

Force is a good thing to have, especially when it comes to getting a new job. How this quality stood one young man in good stead is best told in his own words:

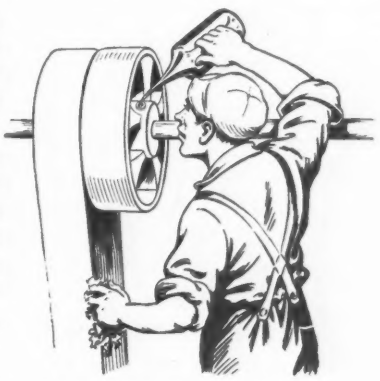
"I landed in Boston, fresh from Liverpool, with a wife and just $12, and no idea where to go to get a job in my line—the machinist's trade. I had been used to mill machinery repairing, so it was only natural that I should inquire as to what city had the most textile mills. The answer was 'Fall River,' so to Fall River I went. After we had put up at a cheap hotel and paid for the night's lodging, I had just $1.75 left.

"The next day was Sunday, but I was up bright and early, determined to start the hunt for a job, because that $1.75 wouldn't last long. It was during rush times, and as I went by one of the mills I could hear the machinery of the repair shop at work. A ten-foot board fence surrounded the mill, but it didn't take me long to climb over and start in the direction in which I heard the machinery running. A watchman saw me jumping the fence and came after me, which simply made me move faster. I soon got inside of the repair shop and the foreman greeted me with, 'Where in blazes did you come from and what do you want in here?' I told him that I came over the fence and wanted a job, and I wanted it bad, too. 'Don't you know you can't get a job here on a Sunday?' the foreman answered. But I could see that he was anxious to get a man, so I told him I would be there bright and early Monday morning if he'd hire me—and he did."

Today that fellow is equipment superintendent of a plant employing thousands of men—and he has prospects for a promotion that his "force" is going to land for him.

How Steve Oiled the Pulleys

The manufacturers of safety set-screws are do-



"—he had his oil-can industriously at work—putting the oil into the hole of the safety set-screw"

"Don't I tole you never to buy any steel but Sheffield?"

ing a great work, but there is one man in the country who, until a few days ago, did not appreciate this. He was the oiler at one of the big machine tool manufacturing plants, and, although he was not strong on the whys and wherefores of the machine shop, he certainly could swing a twenty-foot ladder efficiently for ten hours a day. But he had not been working long before squeaking was heard all over the shop from the loose pulleys on the countershafts. This is the story the boss millwright told us:

"We couldn't imagine what made the loose pulleys squeak, because the oiler was going his rounds regularly and seemed industrious. One day it occurred to me to watch Steve and see just how much oil he used and where he put it. He climbed up his ladder, threw the belt onto the loose pulley, stopping the machine, and commenced looking all over the tight pulley; pretty soon he had his oil-can industriously at work—putting the oil into the hole of the safety set-screw that was used to hold the pulley on the countershaft. He didn't touch the loose pulley at all—simply shifted the ladder and went through the performance on the next countershaft. He was a green Polack, and meant well enough, and after he had been given a lesson in oiling loose pulleys, he made one of the best oilers we have ever had."

When Good Steel was Poor Steel

When it comes to the last analysis, most of the troubles in the machine shop, as well as elsewhere, come from the ever-present human element. So it was with the new manager's troubles at the old Johnson plant that for a few years previously had been run by a young fellow with plenty of money but no brains, mechanical or otherwise. One of his tales has a good moral.

CALLERS WILL PLEASE APPLY TO OPERATOR. INSIST ON AN ANSWER IN A REASONABLE TIME OR A REASON FOR THE DELAY.

"—a placard placed in a conspicuous position near the telephone operator's desk"

"There was one old Dutchman when I came here who had the whole plant buffaloed by his arbitrary methods. He was the boss diemaker, and a mighty good one, too. Like most men of his type, he was not in the least open-minded, and especially was he prejudiced on matters relating to steel. He swore by Sheffield steel and didn't even want to consider any other brand. One day the non-mechanical manager bought a bar of perfectly good American steel and, grudgingly, Dutchy consented to try it out. It seemed that the old chap had a young German friend whom he had brought in to learn the business, and it was to him that the first die from the new steel was given to be made. The die was made and hardened perfectly, but in fitting the punch, the inexperienced diemaker left too much stock to be sheared, and during the shearing-in operation the die cracked, as any other die would have done under the same conditions. In consternation, the young man went to his old boss, who, telling him not to worry, took the die and went to the manager, saying, as he exhibited the broken halves: 'Don't I tole you never to buy any steel but Sheffield? Now you buy some of this no good American steel, and here's what you get!' "

And the sorrowful part of the incident is that "Old Dutchy" got away with it!

Making the Scrap Pile Pay

The superintendent leaned back in his chair and soliloquized as he gazed out through the shop. "There are lots of things in this world that it's all right to mix, but that doesn't apply when it comes to chips from brass, copper, aluminum and steel; we must keep them separate, because the price of scrap is now quite an item."

"See that old fellow out there sweeping up chips?" said the superintendent, as he pointed out through the office window into the shop. "He's the shop sweeper, and up to six months ago we sure did have all kinds of trouble from the mixing of chips. We couldn't seem to keep them separate, and so they brought very little from the junk man. Finally I hit on the idea of paying a piece-work price for sweeping up chips. I offered the sweeper a bonus of $2 a ton for mixed chips, but for clean aluminum, copper and brass chips from other metals the bonus was $8 a ton, and now you'd be surprised to see the way that old chap hustles to keep the chips from getting mixed. He's the first man to put up a holler if one of the workmen doesn't clean up his lathe before he starts on a job of turning different metal from the one he's been working on. The stunt works fine; we save many times the bonus that we pay him for the chips, and, of course, he's happy, too, for he's making more money."

We departed more than ever impressed with the fact that if you want to make money, you must give somebody else a chance to make some, too.

Courteous Treatment of Traveling Men

We recently called at a Connecticut factory, and upon entering the office our heart was gladdened by the sight of a placard, placed in a conspicuous position near the telephone operator's desk, which is reproduced herewith.

What is of greater interest is the fact that we actually did receive treatment in accordance with the sentiment of the placard. It is not necessary that all manufacturers adopt a placard of this nature, but it would be desirable if some of their employes whose business it is to meet the traveling men would act on the suggestion contained therein.

Machinery for the Sweat-shop

We were visiting one of the big contract shops of New York City when our eye happened to catch a lot of twenty-five or thirty light foot presses that were on the floor ready to be assembled. This sight would not have been uncommon in Providence, but in New York it's different, so we buttonholed the superintendent.

"What's the idea on the foot presses—are you making these for the Providence market?"

The shop man smiled as he turned one of the castings over with his foot.

"Would you believe it if I told you those presses are all going to be used in tenement houses over on the East Side?"

"On the East Side? We didn't suppose there was a manufacturing shop in the tenement section of the East Side."

"Nevertheless, there's a good market over on the East Side for these presses," continued the superintendent. "If you should go down through this district any day, you'd find whole families, ranging from little girls of ten to grandfathers of seventy-five, kicking away at these foot presses, set up on kitchen tables, covering buttons by the gross."

"—it would be better if this market did not exist"

On almost every trip we learn of new markets for machinery, but it would be better, it seems, if this market did not exist.

A FOUNDATION FOR MACHINE TOOL DESIGN AND CONSTRUCTION[1]

NECESSITY FOR MORE COMPLETE KNOWLEDGE OF ACTION OF METAL-CUTTING TOOLS AND WORK DONE BY CUTTING LUBRICANT

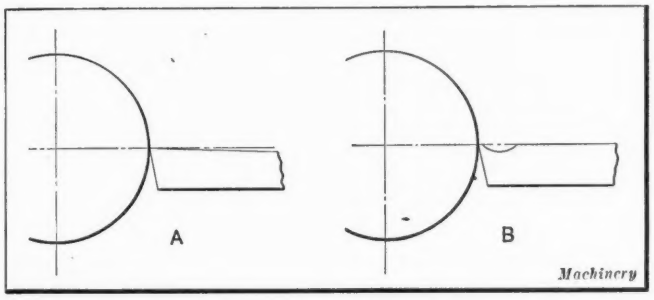


Fig. 1. Cutting with Lathe Tools

THE rapidity of progress of the various branches of engineering may be said to be in proportion to the ease with which their principles can be reduced to mathematics. This was, perhaps, never so clearly shown as in the case of the development of alternating-current apparatus. The mathematics of this branch was waiting for somebody to apply it; as a result, alternating-current apparatus has known no period of experimentation—of stumbling, fumbling progress. Compare this with the slow, hesitating development of the steam engine in its first stages. Nothing was known except that steam would exert pressure, and no knowledge existed of the properties of steam, of thermodynamics, nor of the mathematics of engineering materials.

As soon as the laws of thermodynamics were understood and reduced to mathematics, it became possible to imagine an ideal steam engine, which is another term for a 100 per cent efficient steam engine, and to show what is the maximum obtainable efficiency in any steam engine. It is therefore possible to express the efficiency of existing or contemplated steam engines in percentages of the ideal engine. In other words, the ideal steam engine has become the standard, or unit, of measurement, and it is no longer possible for any designer or builder to think that he has produced a steam engine of the highest possible efficiency merely because his steam engine is twice as efficient as some other existing engine. Mathematical analysis will soon show that his engine is far from the ideal, and a test will show how closely he has approached the product he had intended to build; in other words, he can use his theory to check up his practice. The fact that the inefficiency of the engine is known leaves the door open for further improvement.

Is it possible to develop a theory of the ideal machine tool, such as has been developed for the steam engine? If the only function of a machine tool were the removal of metal, our best machine tool would be found to have an efficiency of from 0.12 to 0.22, which is very low as compared with the efficiency of other machines. If chips could be removed from a piece of work by a straight pull, the ideal machine tool would be one that would remove material with the same expenditure of power as is required by a testing machine. However, the question is whether material is removed by a straight pull. The author does not know what the exact nature of the cutting of metal is, and he believes that he is not alone in his ignorance. To his knowledge, no experiments have been made that establish the true nature of the cutting of metals with a reasonable certainty.

Among the questions that should be answered before machine tools can be designed in a thoroughly scientific manner are the following:

When we turn up a narrow disk by means of a square-nosed turning tool of which the width is greater than the width of the disk, is the action of removing the chips purely a matter of tension? If not, what is it?

Does the front end of the tool have any function at all?

How far from the edge of the tool is the point where the chip strikes the tool?

If the action is purely a matter of pull, and the chip does not strike the top of the tool at the cutting point, but some distance farther back, is it necessary that the cutting edge of the tool be sharp?

What is the nature of the lamination of the chip?

How much power is required for the actual removal of the chip, for the friction between chip and tool, and for laminating the chip?

What would be the best shape for such a turning tool for this particular turning operation?

How does the amount of power vary with the various angles of the tool?

If the turning operation is not as simple as assumed in the first question, if, for instance, there is a side feed, as in ordinary shaft-turning operations, how is the cutting action modified by this side feed?

If the chip is removed by the action of the top of the tool, that is, if the front of the tool has no function, what determines the nature of the finish of a cut?

In what relation does the power required for the side feed stand to the power required for the actual removal of the chip?

Action of a Cutting Lubricant

As dark a subject as the action of the tool itself is the action of a cutting lubricant. It is well known that the use and the nature of a lubricant affect both the finish and the size. If the chip is separated by tension, that is, if the point where the chip begins to separate from the work is some distance ahead of the point of the cutting tool, how can the cutting lubricant affect either the size or the nature of the finish? Another equally puzzling question is: If one of the functions of the cutting lubricant is to reduce the friction between chip and tool, why not use a heavy lubricating oil instead of a light lard oil that has practically no lubricating qualities? Also, if, as facts seem to show, the best results are obtained with a cutting lubricant that has little viscosity and therefore can readily rise between the chip and the work by capillary action, what is the action of the oil on the separation of the chip, seeing that the oil only gets to the point of separation after the chip is separated?

Even more puzzling is the effect a cutting lubricant seems to have on the size of the work. We do not see how it is possible for the lubricant to influence the size, yet that it does has been observed many times. For instance, when twenty-four screws were made on an automatic screw machine, using a mineral oil with 15 per cent lard oil, the screws came true to size within the limit of 0.0005 inch. But when the oil was removed, the machine and tools cleaned, and another cutting compound substituted, not only were all the screws made larger than those cut with the regular oil, but they also varied from 0.0025 to 0.005 inch over size. The machine was once more cleaned and the original oil put back; the screws again came uniform and to size, showing that the cutting of the first twenty-four screws had not dulled the tool nor caused any other disturbing element to enter into the equation. The fact that the cutting compound caused the screws to be over size might possibly be explained by a difference in the heating or cooling effect of the different lubricants; but how can the difference in the size of screws made with the same lubricant be explained when there was no difference in the oil that was employed when the screws were being made?

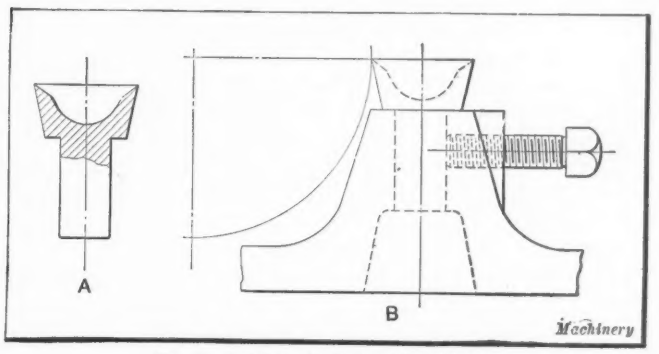


Fig. 2. Small-angle Tool and Tool-holder

[1]Abstract of a paper by A. L. De Leeuw read before the American Society of Mechanical Engineers, at Cincinnati, Ohio, May, 1917.

Proper Angles and Forms of Cutting Tools

The results of an investigation should lie in the direction of saving of power, diminished wastage of tools, and less strain on the machine; or in the direction of increased output with or without the other advantages. That such advantages may be reached seems clear, and the following isolated experiments, though not complete in themselves, point to interesting possibilities.

Forged spindles of sixty-point carbon steel were roughed by a tool like that shown at *A*, Fig. 1, which was able to rough three spindles before a breakdown. In its broken-down condition, the tool appeared as shown at *B*. A hollow had been ground out by the chip, but a land a little more than 1/64 inch wide had been left at the front end, showing that the extreme front of the tool had not been in action. The broken-down tools were carefully measured and new tools of just that shape made, and the hollow was carefully polished. A tool thus prepared would rough from nine to thirteen spindles. Examination showed that the hollow in the tool would remain smooth almost to the last, and that a complete breakdown followed soon after the surface of the hollow began to show scratches. No tests of power consumption were made, but it may be assumed that the power required with the old tool was more than with the new tool, as the chip did not have to

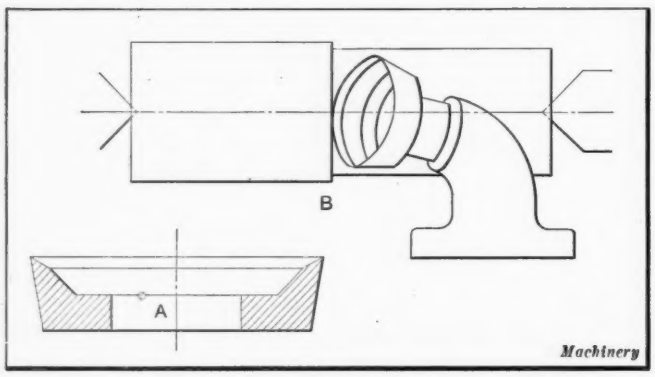


Fig. 3. Rotary Lathe Tool

bend so sharply and the work required for hollowing out the tool was omitted. Another interesting point about this tool was that the actual contained angle between the front of the tool and the front of the hollow was much less than we would have dared to make between the front and top of an ordinary lathe tool, especially if it were to be used for roughing. Nevertheless, under the conditions given, this tool with the small front angle stood up better than the original tool with the large angle.

In his paper "On the Art of Cutting Metals," Mr. Taylor states that his experiments showed no perceptible difference in power consumption for various contained angles of the cutting tool. The author thought that this conclusion would probably be correct only for the range of cutting angles tried by Mr. Taylor. Realizing that an ordinary lathe tool would not stand up with much smaller angles than those used in present-day practice, he devised the tool shown at *A*, Fig. 2, which was held in a rigid block of metal and directly over the lathe carriage, as shown at *B*. The tool was used for turning, preparatory to grinding, milling machine over-arms, about 4½ inches in diameter and 5 feet long. When the tool gave out, it was turned in the tool-holder so as to present a new piece of the edge to the work. In this manner, from twelve to sixteen settings could be made with one sharpening of the tool. The sharpening itself was a matter of circular grinding. The tool would make a very smooth cut, and without a steadyrest would turn half the length of the bar with a variation in diameter of less than 0.003 inch. The surface of the work was unusually smooth, and the amount required for grinding was much less than usual. This matter of the relation of the contained angle to the power consumption for a given cut led to the introduction of the helical cutter, where the actual angle of the tool is not small, but where the tool is presented to the work in such a manner as to have the same effect as a small angle.

Another experiment was an attempt to use a rotary lathe tool, such as is shown at *A*, Fig. 3. The edge of this tool bears up against the work as shown, and there is a very slight difference in speed between the work and the tool. It was set in such a way as to make the virtual cutting angle very small. High cutting speeds had no apparent effect on the tool and the cutting speed was limited only by the machine. With a reduction of 3/16 inch in diameter and a feed of 1½ inch, a cutting speed of 650 feet was used for both cast iron and steel. All cutting was done dry. No attempt was made to get accurate data as to power consumption, as it was realized that the lathe in its present form is not well adapted for this kind of cutting tool. The chips made by this tool were not broken up and were practically solid steel bars; moreover, as they came off the lathe they were cold enough to be caught in the hand.

Suggested Lines of Experimentation

The author believes that interesting results may be obtained by following a line of experimentation such as the following: An instrument should be built, somewhat along the lines of a microtome, in which a soft material is to be cut by a razor-like blade or tool. This tool should be arranged so that it can present various angles to the work, and tools of various contained angles should be experimented with. The angles presented to the work should vary as to clearance, rake and shear. A dynamometer, which should be part of the instrument, should register the pull required for the cut. The material to be cut should be standardized, and it is suggested that paraffin may fill all requirements; by selecting a paraffin of standard melting point, we would also get a material of standard hardness. In this manner, the relation between cutting angles and power required can be established over a wide part of the curve. Though the actual figures obtained will not be immediately applicable to metal cutting, it may be possible to find the controlling law, after which the cutting of harder materials over a small portion of the curve may be studied. The same instrument could possibly be used for tests on such materials as lead, soft white metal, etc.

Another line of experimentation would be to arrange some machine tool, such as a lathe, for running at very low speed, say, one inch per hour; mount a steel disk on this lathe, and take a cut at the circumference of this disk. In this manner the cutting action will be of the simplest kind, as the tool used can be a square-nosed tool of greater width than the thickness of the disk, so that there will be no side cut. A moving picture taken at a high rate of speed can then be reeled off at a low speed, and thus visualize what actually takes place in cutting metal. It will readily show whether cutting is merely the result of tension, whether shear plays a role, or whether both are responsible. It will probably show whether the chip leaves the work ahead of the tool point and whether or not the front end of the tool is in contact with the work. It will show many other things besides, and might be made the foundation for a number of lines of experimentation.

* * *

UTILIZATION OF WASTE

High prices and economies enforced by war conditions have brought about some surprising changes in manufacturing practice, especially as regards the utilization of waste. A shoe manufacturer had for years disposed of small scraps of leather at a low price, as they were considered worthless for any purpose except for making charred leather used in case-hardening. The high cost of leather led him to consider other possible markets for the leather scraps, and, as a result, he is today converting the scraps into straps for slippers and realizes approximately $3500 yearly from material that brought less than one-tenth as much before. The Ford Motor Co. utilizes the waste textiles, pantasote and other materials used in making tops to make spark coil boxes. The material is ground fine and then is fed to a machine having a screw or worm somewhat like a sausage machine, which is capable of forcing the material under heavy pressure into separable dies. The output of the department in which this scrap material is converted into spark coil boxes is more than 3000 boxes a day.

GAGING SYSTEMS FOR SCREWS AND TAPS

DEVICES FOR MEASURING VARIATIONS IN LEAD AND DIAMETER

IN the accompanying illustrations are shown the gaging devices being considered by the subcommittee on gaging systems of the American Society of Mechanical Engineers, in its effort to find a gage that will quickly measure variations in both lead and diameter. The devices shown in Figs. 1, 2 and 5 are suitable for a wide range of diameters and pitches; the other gages are limited to one size of screw or tap.

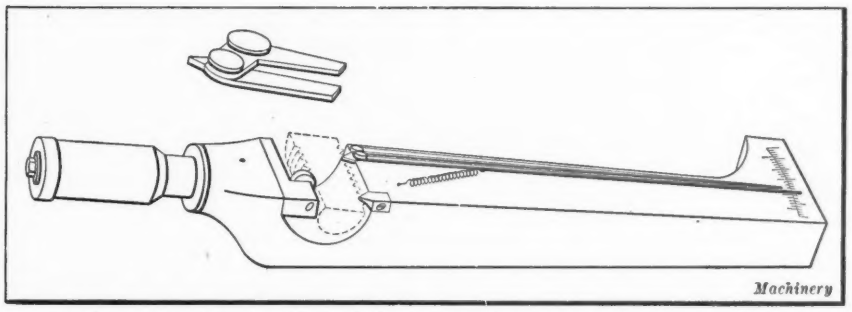


Fig. 1. Gage for measuring Variations in Diameter and Lead of Screws and Taps

The gage shown in Fig. 1 measures the variation from standard of both the pitch diameter and the lead of screws and taps. It is constructed with the fixed V-point, a micrometer adjusted grooved roll, and a floating point. The grooved roll fits over the thread and is free to move sideways to allow for variation in lead. The roll is set to the standard pitch diameter of the work to be tested by the micrometer thimble. A floating point is so connected that the longer lever shows variations in lead, and the shorter, variations in pitch diameter. Work is placed between the points, as shown in dotted lines, and the variations from standard pitch diameter and lead are read directly in thousandths of an inch.

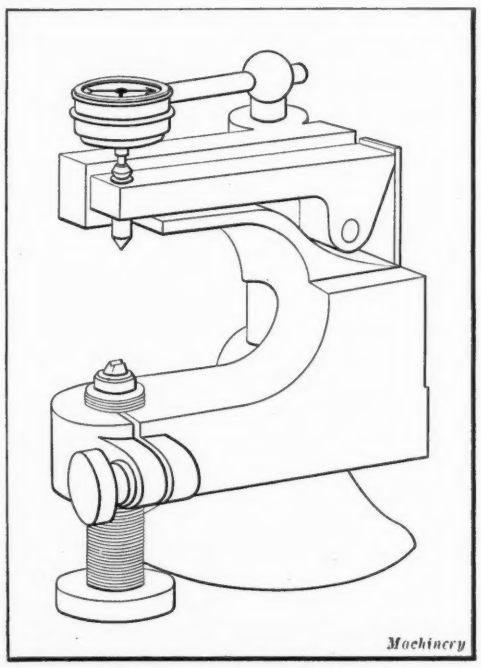


Fig. 2. Gage for measuring Variation in Pitch Diameter

The gages shown in Figs. 2 and 3 are to be used together. That shown in Fig. 2 measures variations in pitch diameter only. The V-shaped anvil is adjustable through a wide range of diameters and can be locked in position by a clamping screw. The gaging arm is pivoted, and the gaging point is held in contact with the work at a constant pressure by a spring at the rear. A dial indicator is in contact with the arm. The gage is set to a standard, and as the work is passed between the points, variations in diameter are transmitted through the arm to the dial indicator, where the amount of variation may be read directly in thousandths of an inch.

The gage shown in Fig. 3 is for testing the lead only. The positive point may be used in any of four positions to allow for different lengths of thread. The floating point is part of the bellcrank lever, which is mounted to act on the dial indicator as the distance between the measuring points varies. After the indicator is set to a standard, the work is positioned on the two points. Any variation from the standard in the lead can be read directly, in thousandths of an inch, on the dial.

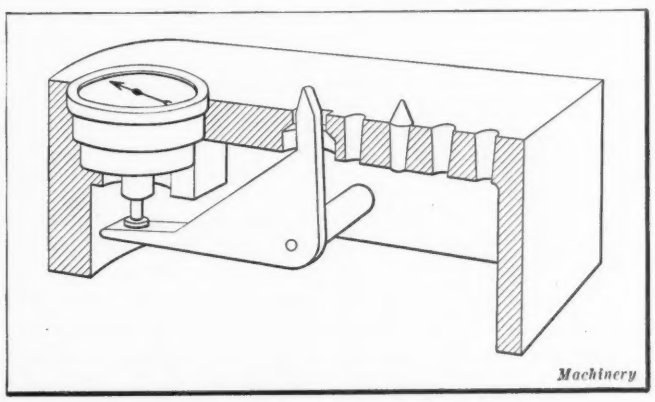


Fig. 3. Gage for measuring Variation in Lead

In Fig. 4 is shown a gage that can be used for pitch diameters only. It is made slightly tapering and is split and furnished with screws for adjusting and locking. It is adjusted so that the setting standard *A* will screw into the gage until a line on the standard matches a line on the gage. The other lines on the gage indicate 0.001 inch variation from the standard in pitch diameter.

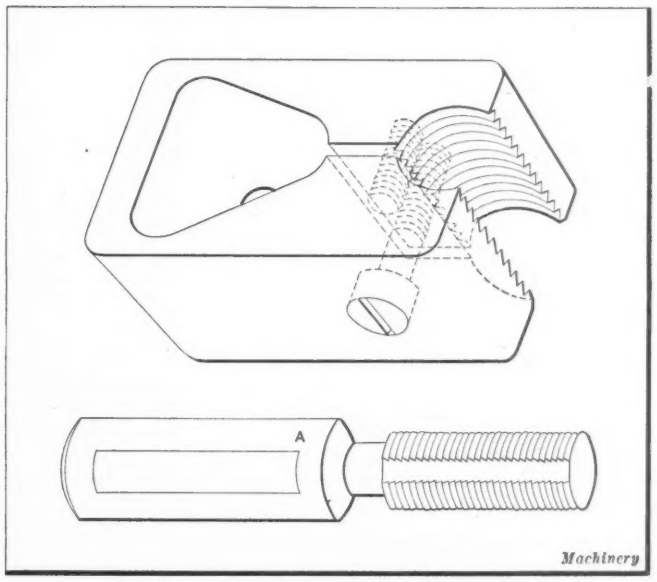


Fig. 4. Split Gage for measuring Pitch Diameters

A combination gage for pitch diameter and lead is shown in Fig. 5. In this gage there is a fixed point and two adjustable points, one for variations in pitch diameter and the other for variations in lead. The errors, in both cases, are read in thousandths of an inch on the dial indicators. The indicators must be set to a standard before testing work. An adjustable block may be set by a vernier so that work resting on it will have its center line in line with the gaging points.

The gage shown in Fig. 6 has three fixed points, located correctly for lead and having a set relation to a flat pin between which and the screw being tested a pin gage is used. This pin gage is of such a diameter that it will "not go" when the work passes inspection as to combined errors of diameter and lead. The work being tested is shown in dotted lines. In Fig. 8 is shown a gage with

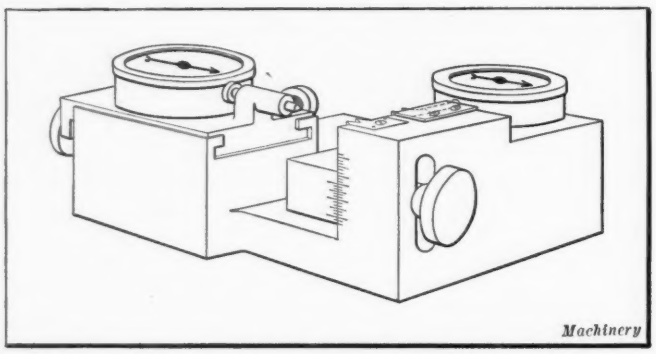


Fig. 5. Combination Gage for measuring Pitch Diameter and Lead

two fixed points, located correctly. Guiding grooves serve to align the work, which is placed in the gage as shown by the dotted lines. The amount of variation from the standard can only be estimated.

A gage fitted with a hinge *F* and spring *G*, like that on a spring caliper, is shown in Fig. 7. The jaws are opened when the screw to be measured is inserted, and are brought together by the fingers. The hole *B* is the "Go" gage. It has a standard thread, and when the flat surfaces between this hole and

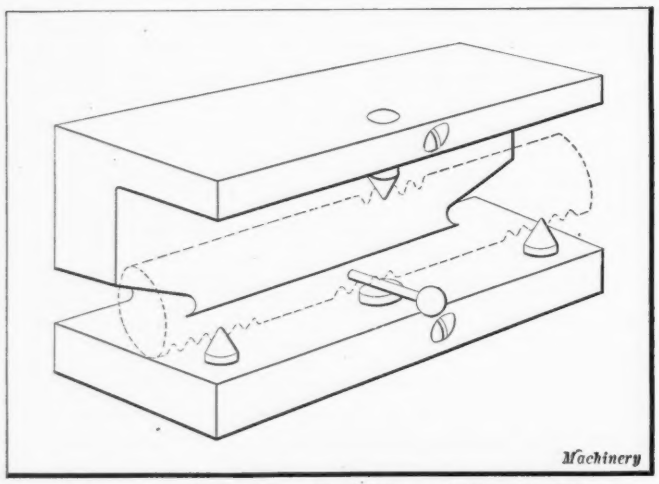


Fig. 6. Gage having Three Fixed Points and Measuring Pin

the end are in contact, any screw that goes in will enter the tapped hole, regardless of the lead error. The other three holes *C*, *D* and *E* are "Not Go" gages and test the root diameter, pitch diameter, and outside diameter, respectively. In order to eliminate the question of lead, in both *C* and *D*, only a single turn of thread of special form, as shown by the enlarged views, is used. The last hole *E* is plain, to gage the minimum outside diameter. The "Not Go" gage *D*, in combination with the "Go" gage *B*, limits errors of pitch diameter and lead also.

The gage shown in Fig. 9 is similar in principle to that shown in Fig. 8. It has four fixed points located in the correct relation to one another. Screws locate the work so that its center line is on the line of the gage points. Work is placed in position and variations in lead and pitch diameter may be estimated.

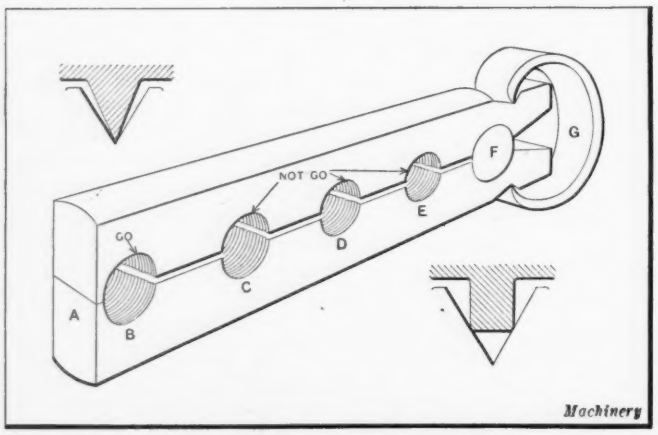


Fig. 7. Combination Gage with Hinged Joint

SUBSTITUTES FOR TIN CANS

The Department of Commerce, in cooperation with the Department of Agriculture, has been conducting an investigation to determine to what extent substitutes can be used in place of tin for packing products. Tin plate is 98 per cent steel and 2 per cent tin. Steel is the backbone of war, and the mills have not been able to keep all their customers fully supplied at all times. It is therefore imperative that substitutes be used for products that can be preserved in containers other than tins. The price of glass has risen so steadily that its use for food containers is impracticable, but fiber or paper containers have been used for many materials with satisfactory results. The fiber containers are made in various shapes and

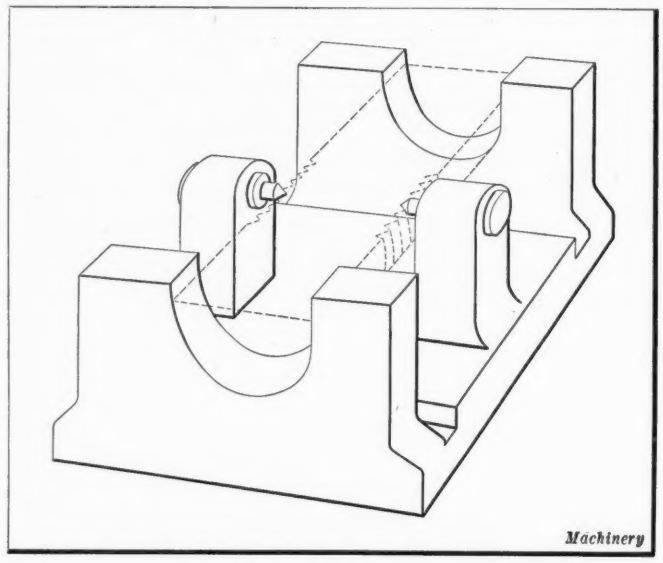


Fig. 8. Gage having Two Fixed Points

sizes adapted for different purposes, and may or may not be coated with paraffin, which is chemically inert and is sometimes baked into the paper material. Some of these containers are claimed to be air-tight, proof against leakage and protected from contamination by the paraffin. Fiber containers are recommended for the distribution by the retailer of many foodstuffs, including milk, cream, buttermilk, ice cream, ices, dried fruits, jellies, mustard and salads. It is also claimed that dried food products, such as coffee, tea, alum, baking powder, prunes, etc., may be successfully packed by producers and manufacturers in paper or fiber containers. Other commodities usually packed in tin could be marketed as well in paper or fiber with the advantage of lower cost. Chief among these is tobacco, and other articles are lye cleansers, soap powders, shoe polishes, toilet articles, such as talcum powder and various dry drugs and chemicals.

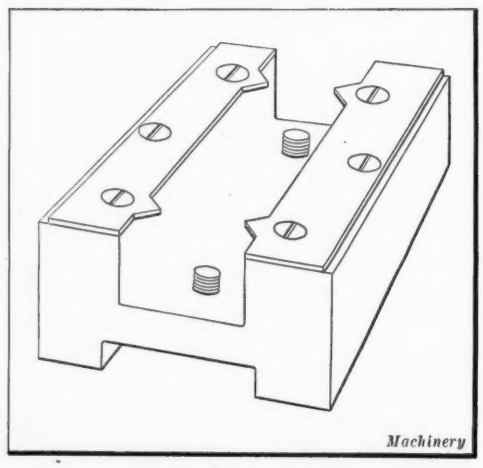


Fig. 9. Combination Gage with Four Fixed Points

* * *

John Younger states in an article on "Retardation," published in the proceedings of the Engineers' Club of Philadelphia, that experience has shown an acceleration or deceleration of six feet per second per second is about all that can be borne in comfort by passengers, and that ten feet per second per second is the maximum. This is equivalent to an applied horizontal pressure on the passenger of about one-third his weight.

TESTING SPRINGS FOR MILITARY RIFLES

FIRING, VIBRATING AND WEIGHT TESTS

BY S. N. BACON

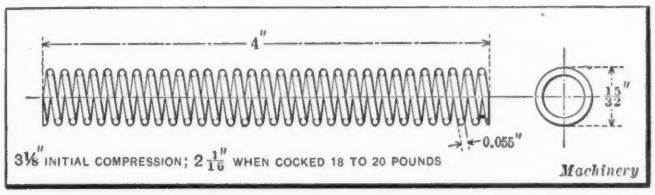


Fig. 1. Firing-pin Spring

A TYPE of firing-pin spring that, with slight variations in dimensions, is used in many foreign military rifles now being manufactured in this country is illustrated in Fig. 1. The specifications require that the spring be subjected to a compression test of forty-eight hours and shall not exceed four inches in length after the test. Each spring is then tested by firing it one hundred times.

The fixture for the firing test, shown in Fig. 4, is mounted in a standard form of punch press having an adjustable stroke. Ten of the springs are loaded into the U-shaped block *A*, which has a handle *B* and is slid against a stop-pin *C* in a groove in the base *E*. The springs are compressed by plungers *F* carried by a plate *G*; a bushing *H* pressed into this plate slides on the center post *I*, which is mounted in the base *E* of the fixture. This plate *G* is lowered by a punch *K* until the spring

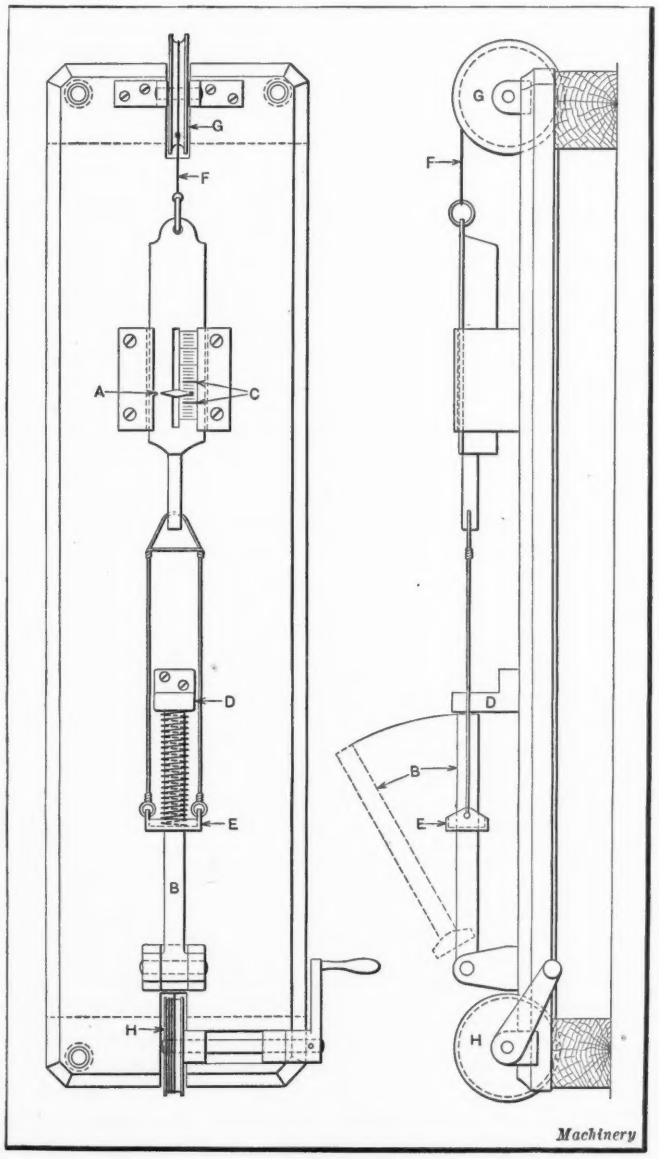


Fig. 2. Weighing Pressure of Firing-pin Spring

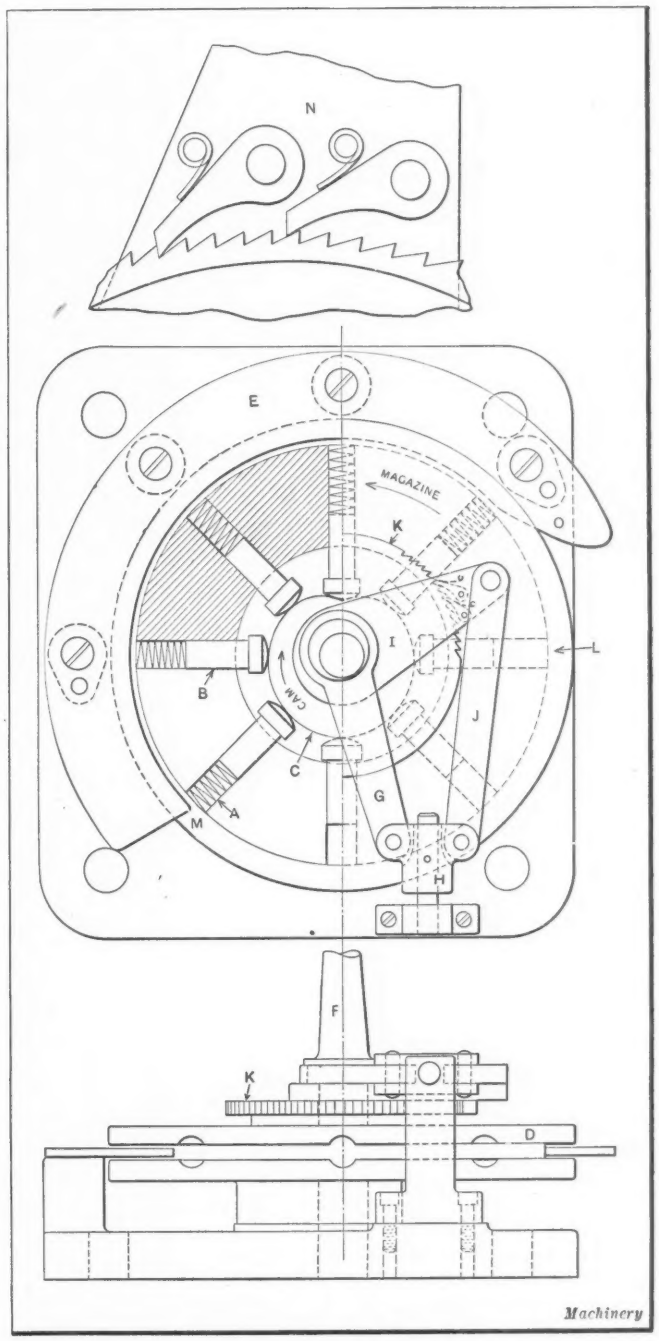


Fig. 3. Making Vibrating Test on Coil Springs

L forces the sear *M* into a pin *N* in the center post. When the adjustable pin *O* descends, it causes the trigger *P* to withdraw the sear, and the plate *G* is shot upward by the springs until it strikes the descending punch *K*, which is protected by a hard paper-fiber pad *Q* that is fastened to the punch as shown. The plate *G* is at once carried downward until the sear *M* locks it in the firing position. The springs, four inches in length, are put into the testing fixture and are compressed to 2 1/16 inches, as shown at *S*, which is equivalent to the amount of compression that the spring is subjected to when the rifle is cocked; the firing is so timed that the springs are released to a length *T* equal to their initial compression length when the rifle is not cocked for firing.

The impact is taken by the punch *K* while on the down-stroke, and on the up-stroke the trigger allows the rod *O* to pass it, and is returned to position by the flat spring *J*. The trigger is carried by plate *U*, which is screwed to plate *G*.

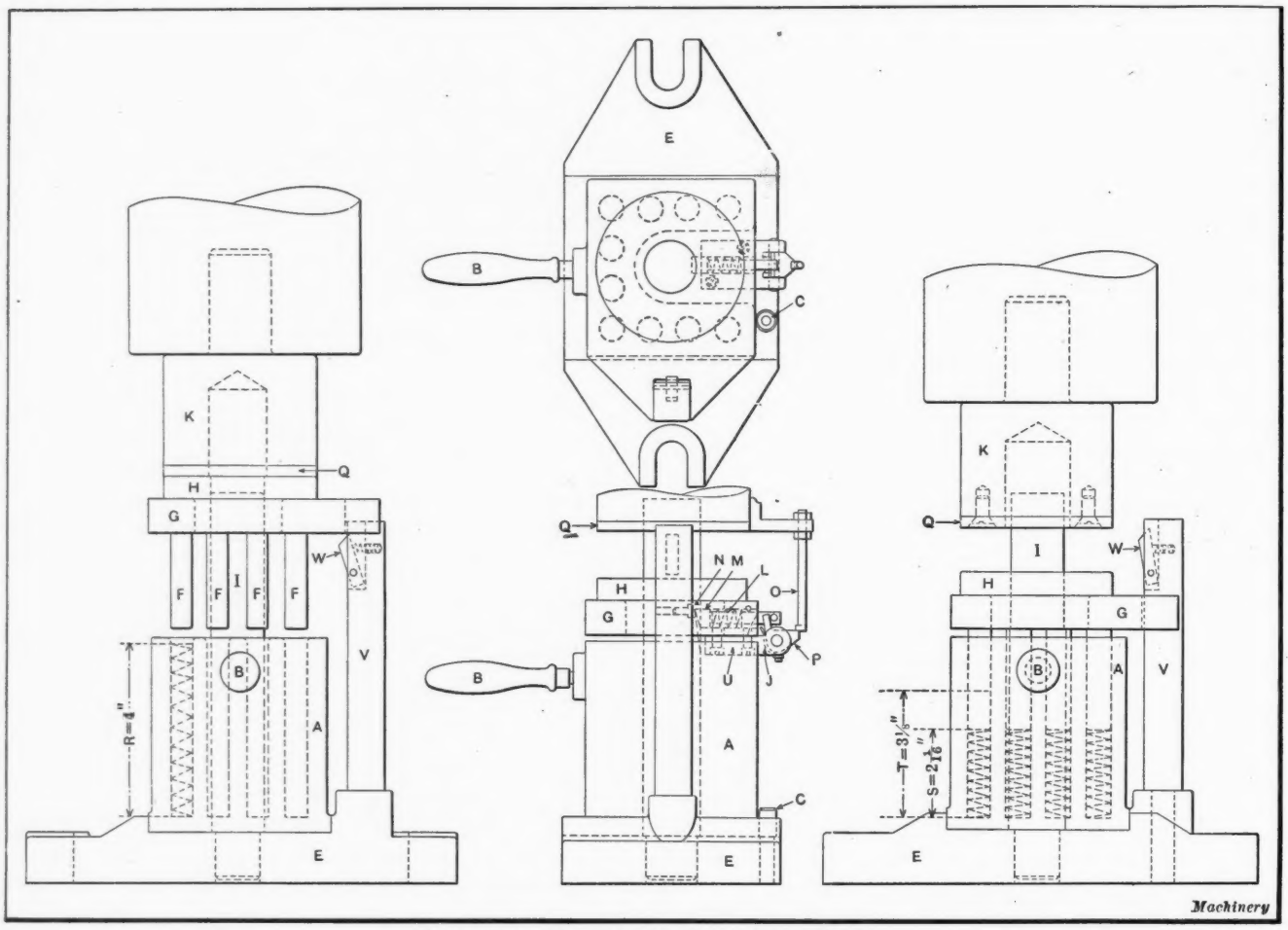


Fig. 4. Fixture for performing Firing Test on Springs

The post *V* keys the plate *G* in position and carries the spring-operated retainer *W* that keeps the plate *G* and plungers in the upper position when loading, thus allowing clearance for removing the loading block. Two loading blocks are furnished with each fixture to enable the machine to be continuously operated. After the loading block with ten springs is in position, the first stroke of the punch causes the plate *G* to escape the retainer *W* and compresses the springs to the length *S;* they are retained in this position by the sear *M* until the punch has returned to the upper position and is again lowered sufficiently for the pin *O* to pull the trigger *P*. An annunciator attachment rings a bell after the springs have been fired one hundred times. The bell-hammer is operated by dry cells, and the electric contact is made after one revolution of a ratchet wheel rotated by a pawl mounted on the ram of the punch press.

Weighing Pressure of Firing-pin Spring

In Fig. 2 is shown a vertical weighing fixture that is mounted on the wall. This fixture is designed to weigh

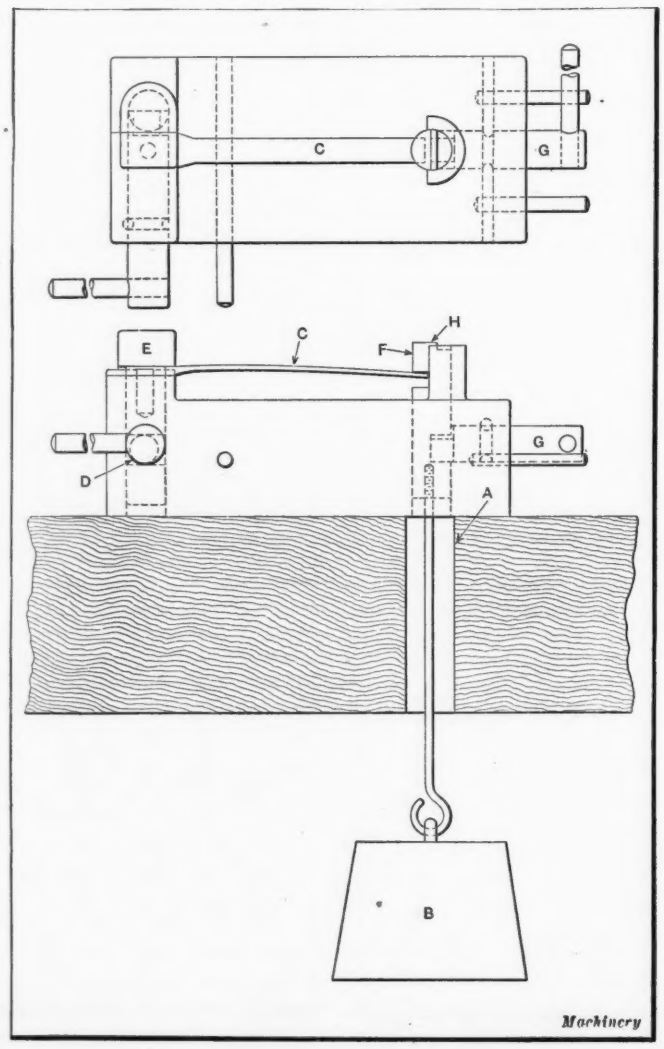


Fig. 5. Testing Temper of Flat Springs

the pounds pressure of the firing-pin spring at a given length. When the special pointer on the scale coincides with the pointer *A*, the firing-pin spring (which is loaded on the swinging pin *B*) has been compressed to its initial compression of 3⅛ inches. The graduations *C* on the standard scale that represent the specified weight of the spring (minimum 18 pounds, maximum 20 pounds) are cut deeper than the others and filled with red wax, so as to be readily distinguished. The spring is compressed against the stop *D* by the swing *E*, which is hung from the scale beam. Its light construction balances the weight of the usual ring and hook, which have been removed. The scale is hung from the pulley line *F*, which runs over the pulley *G* and then down the back of the frame to the drum *H*, operated by the crank shown. This crank affords a sensitive control over the scale beam, as the leverage of the crank allows the spring to be easily compressed. The swing *E* is lowered until the spring attains its free length before the pin *B* is swung out for reloading with another firing-pin.

Vibrating Test

The other coiled springs used in military rifles do not require the shock test described for the firing-pin spring, but they do require a vibrating test of one hundred strokes each. A fixture for making this test in a drill press is shown in Fig. 3. The springs *A* are compressed by the plungers *B*, which are operated by a heart-shaped cam *C* fastened to the spindle *F*. The springs and plungers are carried in the rotating magazine *D*, which has a bearing in the base of the fixture to which is fastened the semicircular guide *E*. Spindle *F* has a No. 2 Morse taper shank to fit the spindle of the drill press. An eccentric mounted on spindle *F* transmits motion to the arm *G* and the slider *H* that rotates arm *I* by means of connecting link *J*. Two pawls mounted on arm *I* rotate ratchet wheel *K* and magazine *D* independently of the spindle.

In operation, the drill-press spindle and cam *C* are revolved at about 120 revolutions per minute, and the cam compresses the springs once each revolution; it will be seen by referring to the illustration that a spring is loaded at *L* and travels 180 degrees within the guide *E* before being ejected at *M*. Hence, since the spring must be compressed 100 times before being ejected (or while passing through a distance of 180 degrees), the speed ratio of the cam to the carrier must be 200 to 1. For this reason a ratchet of 100 teeth is operated by the double pawl action shown at *N*, which indexes the ratchet wheel one-half tooth at a stroke; this is equivalent to using a ratchet wheel of 200 teeth, so during one hundred revolutions of the cam the carrier makes one-half turn, thus compressing each spring one hundred times, as required for the test. The guide *E* (which compresses the springs at *O* to the length required when assembled) fits into the circular slot in the carrier *D*, thus keeping the springs inside the rim of the carrier to prevent them from dragging. A tin chute at *M* conveys the springs into a container from which they are ejected. When loading, the operator keeps his finger on the spring until it passes under the guide *E*, so that it will not be pushed out of the fixture by the cam.

Testing Temper of Flat Springs

Flat springs for military rifles must be tested to determine the proper temper for resisting a specified weight. A convenient method of making this test is shown in Fig. 5. The fixture is fastened to the work-bench, in which a hole *A* is bored to allow the weight *B* to be suspended. The spring *C* is clamped by the eccentric clamp *D* operating the hook-bolt *E*; the other end of the spring is located in the notch of the gage plunger *F*. After the spring is clamped in position, the weight and plunger are lowered by means of the eccentric *G*, and the resistance of the spring is noted at the stepped gaging point *H*.

* * *

AIDING MANUFACTURERS TO LOCATE IN NEW YORK CITY OR VICINITY

The Merchants' Association of New York offers the manufacturers about to locate in New York City or vicinity services entirely without charge to aid in securing a desirable location. The problem of finding a good location is an intricate and puzzling one. This is not strange in view of the fact that the industrial district of metropolitan New York contains twenty important cities and many smaller communities, in addition to the five great boroughs of Greater New York. For several years the association has performed a valuable service to such manufacturers in aiding them to select the particular location best suited to their requirements and furnishing them with information relating to the many industrial factors with which they may be concerned. All manufacturers thinking of locating in New York City or vicinity are urged to communicate with Alfred S. Smith, manager of the Industrial Bureau of the Merchants' Association of New York, 233 Broadway, New York City.

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PROGRESSIVE FRACTION ADDER

Fred J. Perry, Nashua, N. H., the maker of the progressive fraction adder shown in the March number of MACHINERY, has received a number of requests for the adder, but he is not making it for sale, and therefore is unable to supply it.

WORKMEN'S COMPENSATION ACTS

BY CHESLA C. SHERLOCK[1]

In a consideration of the compensation acts the question naturally arises, Who are employers and who are employes within the meaning of the law? Section 13 of the British act defines an employer as including any body of persons, "corporate or unincorporate, and the legal representative of a deceased employer; and where the services of a workman are temporarily lent or let on hire to another person by the person with whom the workman has entered into a contract of service or apprenticeship, the latter shall, for the purposes of this act, be deemed to continue to be the employer of the workman while he is working for that other person."

To many business men it may seem a little beside the question to discuss who are employers. Such a question is easily determined in most cases, but the real importance attaches to the exceptions and not to the general rule in discussions of this nature. If a firm employs a workman and he receives an injury for which he is entitled to compensation under the compensation acts, it may be an easy matter to say that the firm is the employer and is liable. But suppose that the firm is a partnership, one partner of which is insolvent, and that he is the one employing the injured workman. Naturally, the workman wishes to hold the responsible partner for compensation. Then, again, a serious question or doubt may be raised as to whether one is an employer at law, even though he has actually engaged a workman to perform certain duties for him. For instance, is the owner of a threshing machine the employer of a man known as a "trusser" who accompanies a machine from place to place but who receives his wages from each farmer? It was shown, in a given case, that a trusser rendered incidental services to the owner of a threshing machine in going from farm to farm, by riding ahead of the machine and clearing the way for it. Although there was absolutely no pecuniary relation whatever between the owner of the machine and the workman, the court held that the workman, if injured, was able to collect compensation from the owner of the threshing machine on the theory that such owner was the workman's employer. In a Scottish case the court said:

> A coal trimmer, although employed by an agent of the harbor commissioners, is in the employment of a firm of shipping agents who act as managers of a vessel being loaded with coal for third persons, where the trimmers are directly under the control of the agents and are paid from the freight, the balance of which, less charges, is sent by the agents to the owners of the vessel.

In another case, it appeared that the owner of a ship, being in a hurry, gave some money to a stevedore and asked him to employ a workman to assist in mooring the ship. In endeavoring to do this the workman was injured. The court held that the owner of the vessel was the employer, although the stevedore had actually employed the workman. Other questions arise where there is more than one employer and where the workman is admittedly the employe of one of them. The courts have, of course, decided cases on this point, but they have not decided them by virtue of the compensation acts, but by rules of law entirely independent of these acts.

There can be no recovery for injuries under the English act unless there is a contract of service between the employer and the employe. This is a question that is fruitful of litigation, but one that is determined, not upon the compensation acts, but upon rules of law entirely independent of the acts.

The section of the British act defining workmen reads:

> "Workman" does not include anyone employed otherwise than by way of manual labor whose remuneration exceeds £250 a year, or a person whose employment is of a casual nature and who is employed otherwise than for the purposes of the employer's trade or business, or a member of the police force, or an outworker, or a member of the employer's family dwelling in his house, but, save as aforesaid, means any person who has entered into or works under a contract of service or apprenticeship with an employer, whether by way of manual labor, clerical work, or otherwise, and whether the contract is express or implied, is oral or in writing.

[1]Address: Box 253, Des Moines, Iowa.

In one of the leading cases on this question, the court said:

> The popular meaning must be given to a definition where we are confronted with such an expression as "wages," and we must interpret the act as applying to persons whom, *ex hypothesi*, the legislature regards as not being in a position to protect themselves. None of these considerations apply in the case of a person holding the position of a certificated manager of a colliery, who comes within a very different category from that of an ordinary workman. I do not say that a person in the position of the deceased is absolutely excluded from the possibility of coming within the act, for it is possible that such a man might in fact work as a workman, though I do not know that such a contingency is at all probable; there might, however, be facts in a particular case from which the conclusion might be drawn that, although the man was a certificated manager, he was also a workman.

In another important case, the Master of the Rolls said: "The root of the matter is that each case must be decided in view of that which the person whom it is sought to treat as a workman was employed to do." These rules for classifying workmen may seem to be the essence of simplicity, but in most cases the status of an employe can be brought into question. The law cannot be an exact science, even though it is oftentimes so charged by ill-informed persons. The law can only hope to establish guide posts along the way, and each case, under the direction of the court, must find its own way. Partners are not workmen within the meaning of the acts, nor are servants employed in the master's house. A Scottish court even went so far as to say that a son, twenty-six years of age, who was employed as other workmen, but who lived in his father's house and paid his own board and rent, was, nevertheless, a member of the employer's family and could not recover compensation, as he was not a workman within the meaning of the law.

The question of who are workmen is one that is often technical and involved, but in the vast majority of cases it is either defined by the state laws or can be determined by good, sound sense. The majority of our compensation laws are based upon those of England, so it will not be amiss to take into consideration the English interpretation. A spirited question has confronted the courts in whether or not an independent contractor is a workman within the acts. The English courts early found that this question would have to be settled by general principles and could not be considered under the acts, inasmuch as the law did not define an independent contractor. They have held, however, that the mere fact that a workman contracts to do a job by the piece should not dispossess him of compensation. Under this principle, a workman employed in a quarry at so much per ton of stone that he got out, was allowed to recover compensation; also a coal miner under similar conditions was permitted compensation.

It should be kept in mind that the original theory of the compensation acts was that if a workman had, by the product of his skill or labor, enriched society through his added contribution to production, society should bear any losses that he sustained in working for its advancement; in other words, industrial injuries were a part of the cost of production and should be borne by the consumer just as other costs of production are borne. The proposition that confronted the legislators in the first instance of compensation acts was what would be done if a workman had been employed only a short time prior to his injury. Would it be consistent with justice to force society to pay for something that society had not received? A workman employed only a day or so before injury has not had an opportunity to contribute anything to society. The legislators then and there wisely settled a question that might have caused serious disputes between capital and labor. They provided that there could be no compensation for a mere temporary or casual employe.

The question of what is meant by "casual employe" is one that has been bitterly fought in the courts, but has been settled according to common sense and fairness. The rule is this: That irregular intervals of employment are not the proper criterion, but that if an employe is employed at intervals more or less regular, he is held to be a workman under the act. Perhaps the word "casual" is ill chosen; it seems that the word "incidental" or "temporary" would come nearer expressing the light in which the courts regard the meaning of this term than the term itself. If a man is working at something incidental to his main duties, he is a casual employe. If he is for the time being sawing wood, waiting for his plow to be repaired, he is a casual employe. If he is milking a cow when he was employed to build fences, he is a casual employe. If he is wandering past a mill and applies for work and is injured the next day, he is a casual employe. This class of workers is justly ruled out from the benefits of compensation. Of course this does not mean that where a man intends to follow his employment indefinitely and his employers are of the same mind, he cannot recover compensation if he is so unfortunate as to be injured within a short time after entering upon his duties. This is a fact that will be taken into consideration by the court in arriving at the rights of the respective parties.

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EDITORIAL CONFERENCE

A conference of more than ordinary interest and importance was held at the New Willard Hotel, Washington, D. C., May 25, between the editors of the trade and technical press and the Cabinet heads and special representatives of the government engaged in mobilizing the vast and varied resources of the nation for war purposes. The meeting was initiated and organized by the Editorial Conference, which is the name of the society of trade and technical press editors, with headquarters in New York City.

The purpose of the conference was to bring about closer cooperation between governmental activities and the industrial press of the country, and all the leading trade, class and technical journals were represented at the meeting, which was addressed by Newton D. Baker, Secretary of War; Josephus Daniels, Secretary of the Navy; Franklin K. Lane, Secretary of the Interior; William C. Redfield, Secretary of Commerce; William B. Wilson, Secretary of Labor; Dr. Van H. Manning, Director of the Bureau of United States Bureau of Mines; Herbert C. Hoover, Food Administrator; Walter Gifford, Director of the Council of National Defense; Frank A. Scott, chairman Munitions Board, Council of National Defense; Frank A. Vanderlip, president of the National City Bank; Howard Elliott, member of the Executive Committee, Council of National Defense; Dr. Franklin H. Martin, in charge of Red Cross work, medicine and sanitation, Council of National Defense; George Creel, chairman, Committee of Public Information; Dr. Pearson, president of the Iowa State College, now affiliated with the Department of Agriculture; and Lewis B. Franklin, in charge of the distribution of the Liberty Loan bonds. These men are grappling with problems of great magnitude, which, as Secretary Baker said, are the "mobilization of the industry and resources of the United States. . . . War has become a thing of industry and commerce and business. It is no longer Sampson with his shield and spear and sword and Goliath with his sling; it is no longer selected parties representing the nations as champions in physical conflict one with the other; it is the conflict of smokestacks now; it is the combat of the driving-wheel and of the engine, and the nation or group of nations in a modern war which is to prevail is the one which will best be able to coordinate and marshal its material, industrial and commercial strength against the combination which may be opposed to it."

These are the basic truths which the industrial press of the country must bring home to the men who operate the industries of production and distribution. As Secretary of Labor Wilson said, "Under warfare as it is now conducted, more people are required in the industries in the rear for the support of an army than are required in the trenches at the front." We must be united, each must do his part, and each is of prime importance. This is true whether your business is the managing of an enterprise or a department, or operating a lathe, planer or any other machine. Whatever your employment, the great thing is to keep busy—to keep the wheels of industry turning. That way lies the earliest and surest peace.

This was the lesson of the Editorial Conference at Washington, which, in all respects, was a decided success.

GRIDLEY MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE—2

DESIGN, CONSTRUCTION, OPERATION, TOOL EQUIPMENT AND ATTACHMENTS

BY DOUGLAS T. HAMILTON[1]

THE change-gear mechanism on the Gridley multiple-spindle automatic is of such interest that further description may be desirable. In the first place, with this type of machine it is not necessary to start with a machine operating at its maximum efficiency. As a general rule, when an operator is setting up a new job, the first thing he considers is the speed at which he can run the work. Then, if necessary, the change-gears are replaced by those giving the desired spindle speed. He then proceeds to set the various cutting tools, paying no attention to the feed of the turret slide or forming and cutting-off slides. After every tool has been properly set, he then speeds up the machine by changing the levers on the speed gear-box until he obtains a speed as great as the limiting tool will stand. The feed given the tool is then determined in relation to the spindle speed. For instance, on the change-gear box the series of feeds obtainable are 75 to 200 in the following ratios: 75, 100, 125, 150, 175 and 200. This means that the work-spindle makes this number of revolutions to one-inch travel of the tool-slide. With this arrangement, of course, it can be easily seen that it is a comparatively easy matter to obtain a suitable feed, and this can be done while the machine is in operation. It also helps an operator to run the machine more economically, especially when the stock varies considerably in hardness. The change-gear box lever is adjusted with reference to the cams on the drum for operating the turret slide, and each of the three positions for the lever is marked according to the throws of the cams used. For instance, on the ¾-inch size, the positions would be marked 1 1/2, 3 and 4 9/16, respectively. The lever is then put in the hole that is marked to

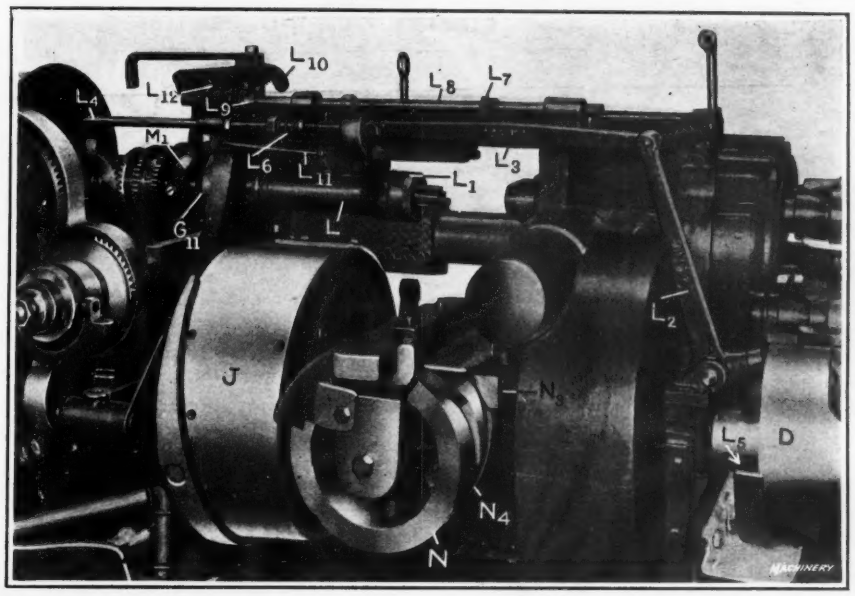


Fig. 21. Arrangement of Die Mechanism for Right-hand Threading on Gridley Automatic

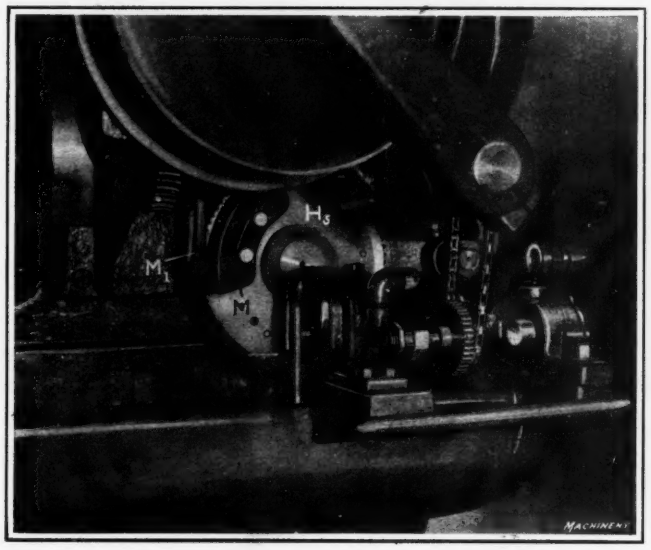


Fig. 22. Cam Position for operating Clutch for Right-hand Threading

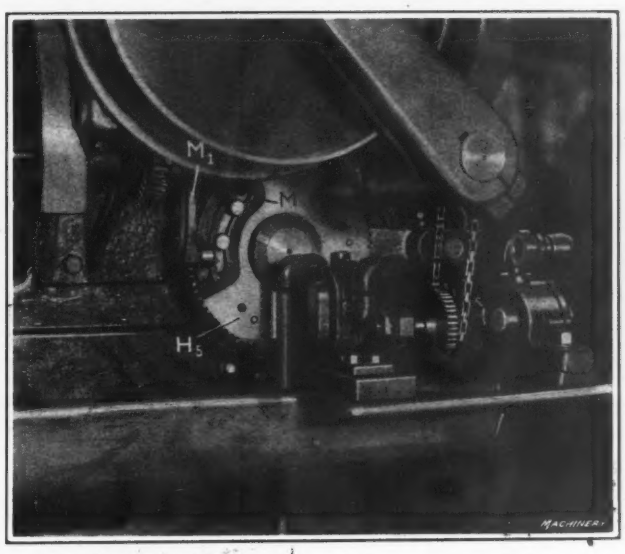


Fig. 23. Cam Position for operating Clutch for Left-hand Threading

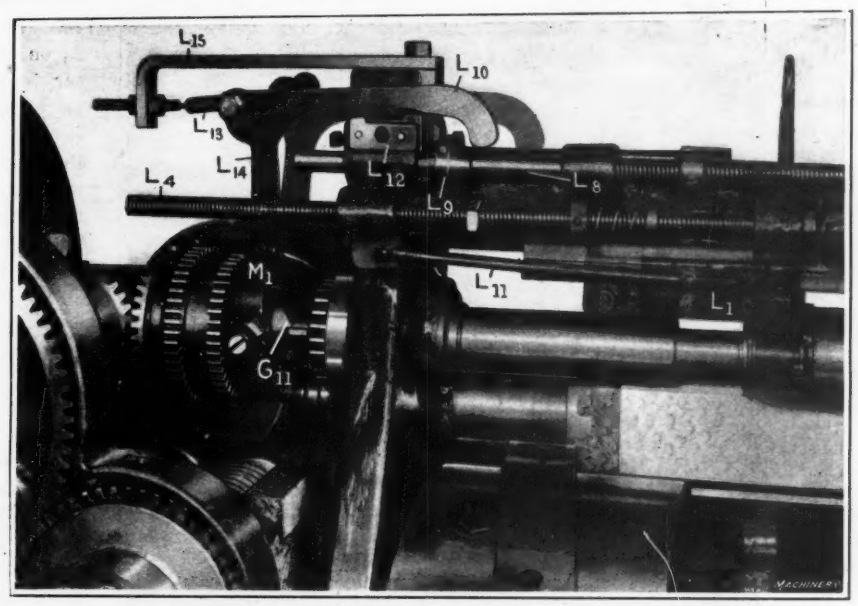


Fig. 24. Arrangement of Die Mechanism for Left-hand Threading on Gridley Automatic Screw Machine

[1] Address: Fellows Gear Shaper Co., Springfield, Vt.

correspond with the throw of the cam used on the turret drum.

The threading mechanism on the Gridley multiple-spindle automatic screw machines comprises a separate and independently driven die-spindle L, as shown in Fig. 21. The gear end of this mechanism is clearly illustrated in Fig. 18 in the June installment of this article. The die-spindle extends through the main frame of the machine and carries the loose gear K_2, the loose combination gear G_9, G_{10}, and the sliding clutch

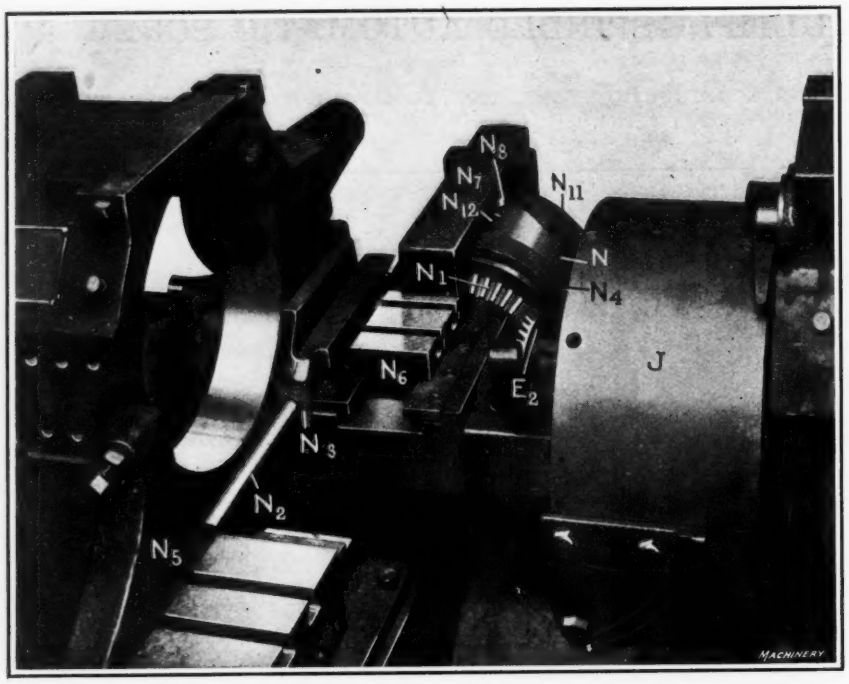


Fig. 25. View of Machine showing Method of operating Forming and Cutting-off Slides

Bracket L_1 is drawn forward through the action of a bellcrank lever L_2, connecting-link L_3 and screw L_4. The die is started by means of cam L_5 on drum D, contacting with the roll on bellcrank lever L_2. When this cam comes into play, it draws screw L_4 to the right and compresses the spring L_6 located between the adjusting nut and washer shown.

In operation, the cam L_5 advances the die toward the work and when the roll reaches the high point of the cam, the spring L_6 is compressed, the spring action assisting the

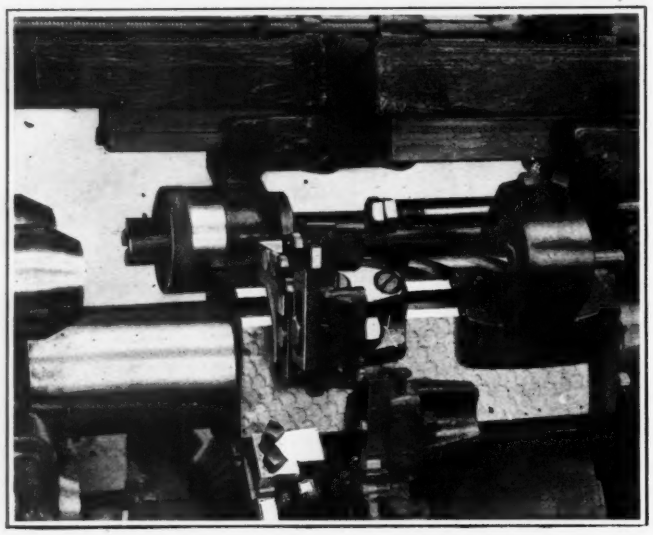


Fig. 26. Method of locating One Turret Tool behind Another

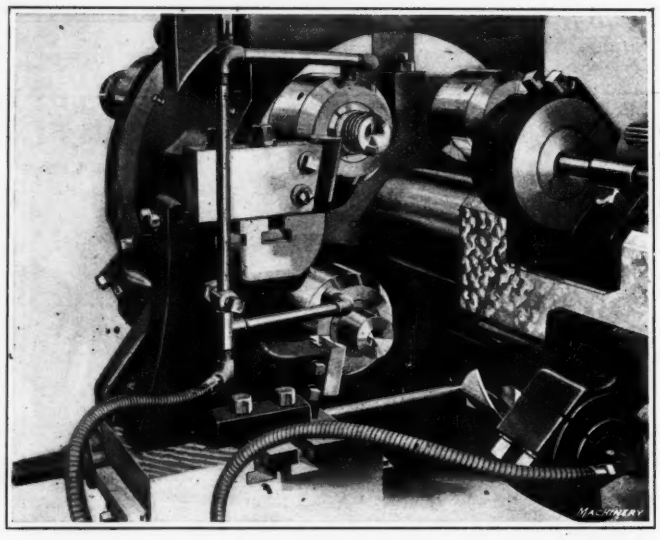


Fig. 27. Rough- and Finish-forming Tools in First and Second Positions

G_{11}, which engages with clutch teeth on the loose gears K_2 and G_{10}. The loose gears G_9, G_{10} and K_2 are driven by gears K and K_1 fastened to the central driving shaft, which drives the spindles.

When right-hand threads are being cut clutch G_{11} is engaged with gear G_{10}, and when the die is being run off from the thread the clutch is engaged with gear K_2. When left-hand threads are being cut, clutch G_{11} engages with gear K_2, and when the die is being run off from a left-hand thread, the clutch is engaged with gear G_{10}.

The method of operating the threading mechanism for right-hand threading is shown in Fig. 21. The threading spindle L is supported on a bracket L_1 that is guided by a slide on the bracket connecting the feed and spindle end of the machine.

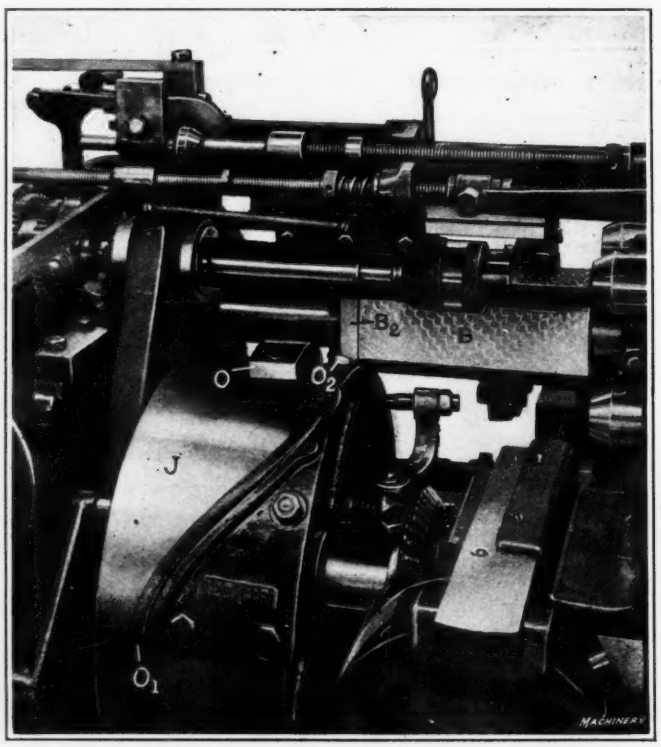


Fig. 28. Detailed View showing Cam for operating Turret Slide

die in starting. The die-slide is then carried forward by the lead of the thread until the boss on the slide reaches the adjustable stop L_7 on screw L_8, when the latter is pulled along with the slide until spool L_9 trips lever L_{10}. This lever, in turn, through the action of a spring, operates clutch G_{11}, throwing it into engagement with the other gear so that the die runs off the work. The slide is then returned to its rear position through the tension of spring L_{11}. This spring, which is put under tension when the slide advances, prevents the die or tap from dwelling on the work and "chewing up" the thread. Just prior to the indexing of the spindle carrier, the return cam throws the die-slide back to the rear position. The clutch is reengaged to drive the die-

spindle at the proper speed after the die backs off the work by a cam M held on worm-wheel H_8, as shown in Fig. 22. This cam comes into contact with the lower end of clutch lever M_1. Cam M also resets lever L_{10} on cam L_{12}, Fig. 21. With this arrangement it is possible for the die to thread a piece and immediately run off without waiting for the turret slide to return to the rear position. It is impossible, except in extreme cases, for the threading operation to be the longest single operation — or, in other words, the operation that controls the time required to produce one complete piece.

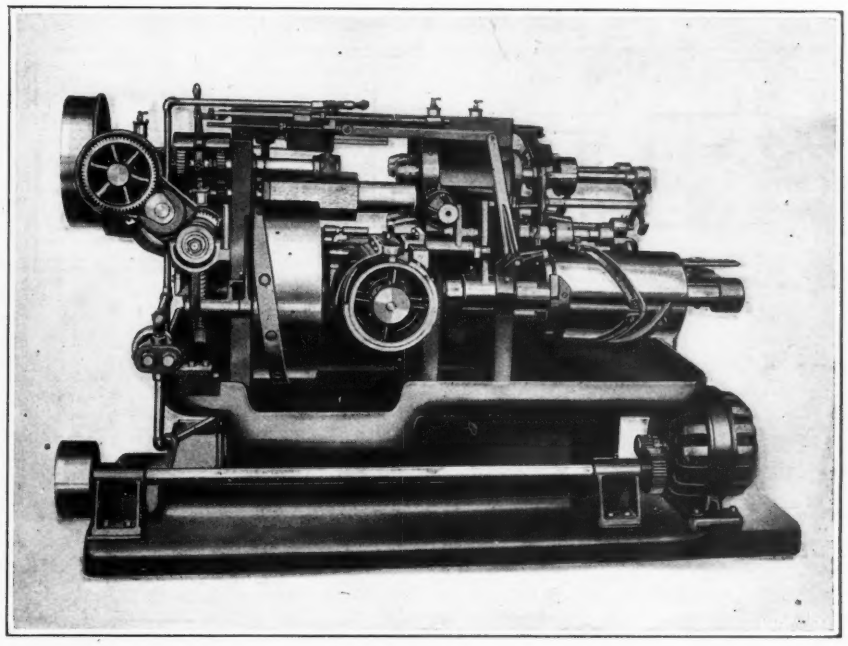


Fig. 29. 1¼-inch Gridley Multiple-spindle Automatic Screw Machine with Motor Drive

For cutting a left-hand thread, it is simply necessary to make a few changes in the arrangement of the tripping cam and springs, as shown in Fig. 24. Here it will be noticed that cam L_{12} is reversed so that it catches the rear instead of the front notch in lever L_{10}. The position of spring L_{13} is also changed, being attached to the clutch lever L_{14} and to the bracket L_{15}. The spring tends to keep the clutch in mesh with the high-speed driving gear on the pulley shaft and thus rotates the die at a faster speed than the spindle, so that it advances on the work; when the die advances to the point desired, spool L_9 trips lever L_{10} and throws the clutch into the slow-speed gear, causing the die to back off the work.

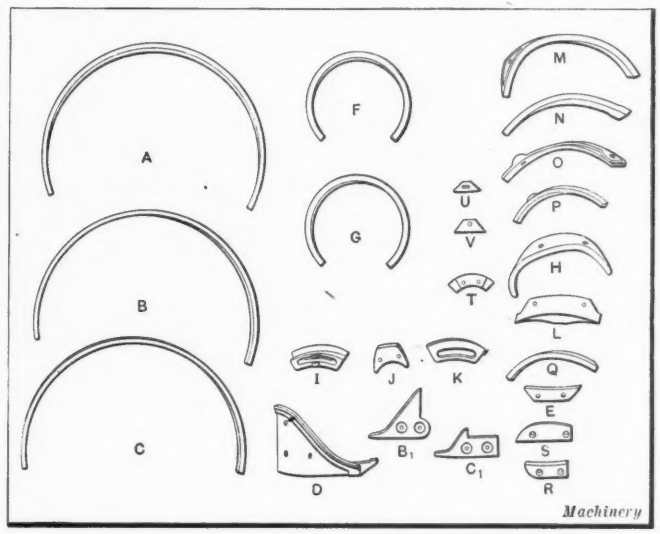


Fig. 30. Various Cams, Dogs, etc., used on Gridley Automatic

The trip is reset by a cam M on worm-wheel H_8 as shown in Fig. 23, which operates clutch lever M_1 in the opposite direction to that in which it moves for right-hand threading.

Operation of Forming and Cutting-off Slides

As has been previously mentioned, the forming and cutting-off slides are operated from a separate cam drum N as shown in Fig. 25, which is held on a shaft that is located at right angles to the main cam drum. The forming and cutting-off cam drum is driven from the main shaft through bevel gears E_2 and N_1. The drum N carries the cams for operating the forming and cutting-off slides. The forming slide is operated through a rod N_2, which is held in slide N_3 supported in a slot in the bed of the machine and also by a bracket located on top of it. This slide carries the roll which runs in contact with cam N_4 on the cam drum, as shown in Fig. 21. The rod N_2 is connected to the forming slide as mentioned, and has an adjusting collar for depth at its forward end, which is graduated in thousandths of an inch, as shown in Fig. 32. The top face of the forming slide has two T-slots in it for clamping the forming-tool holder in position. It also carries a bracket N_5, holding an adjustable stop that comes in contact with stops B_4 in the arms of

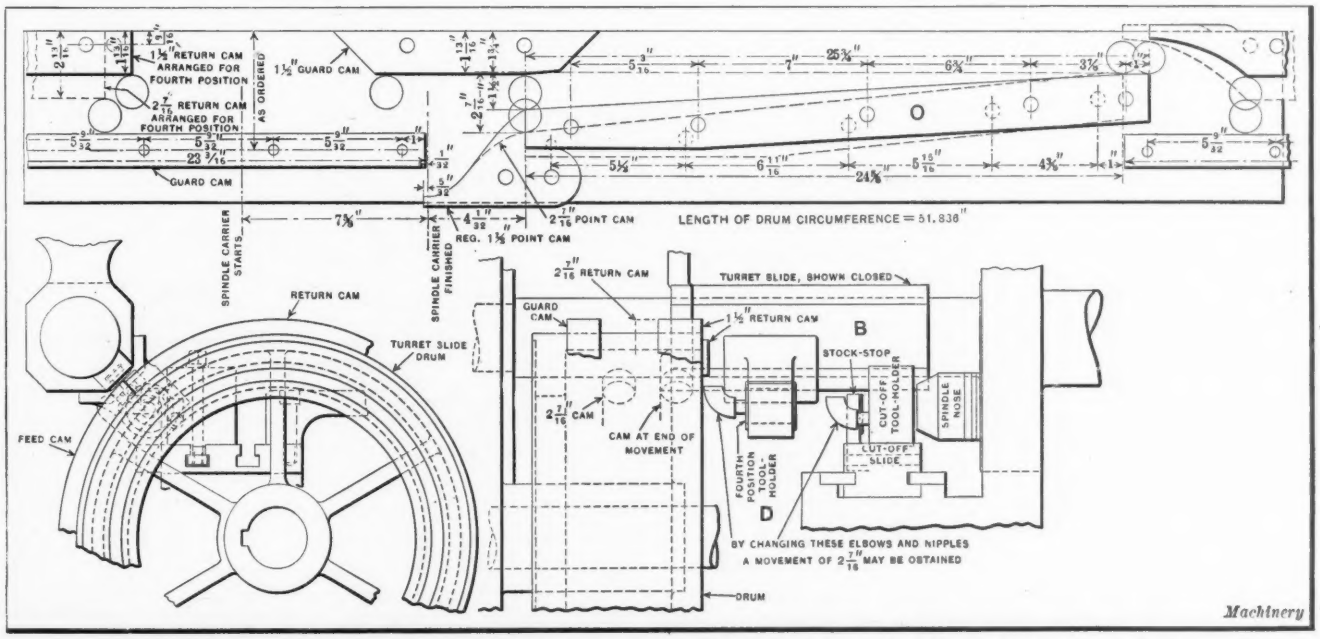


Fig. 31. Diagram illustrating Change made in Lead Cam for operating Turret when End-working Tool is in Fourth Position

the forming ring B_3 on the spindle carrier.

The cutting-off slide N_6 operates in a groove cut in the bed and is held down by gibs as shown. It is operated from cam drum N through a connecting-bar N_7 that has a roll N_8 attached to its lower face. The adjustment of the cutting-off slide is accomplished by changing the position of the roll, which is adjusted by set-screw N_9 and locked by screw N_{10}. The roll is operated upon to advance the slide by cam N_{11} and returned by cam N_{12}, Fig. 25. Both cutting-off and forming slides can be adjusted vertically to compensate for wear by means of taper gibs, as shown in Fig. 32, upon which the slide moves. These gibs are moved in to raise the slides when they have become worn down below the correct center distance by means of a collar screw as illustrated.

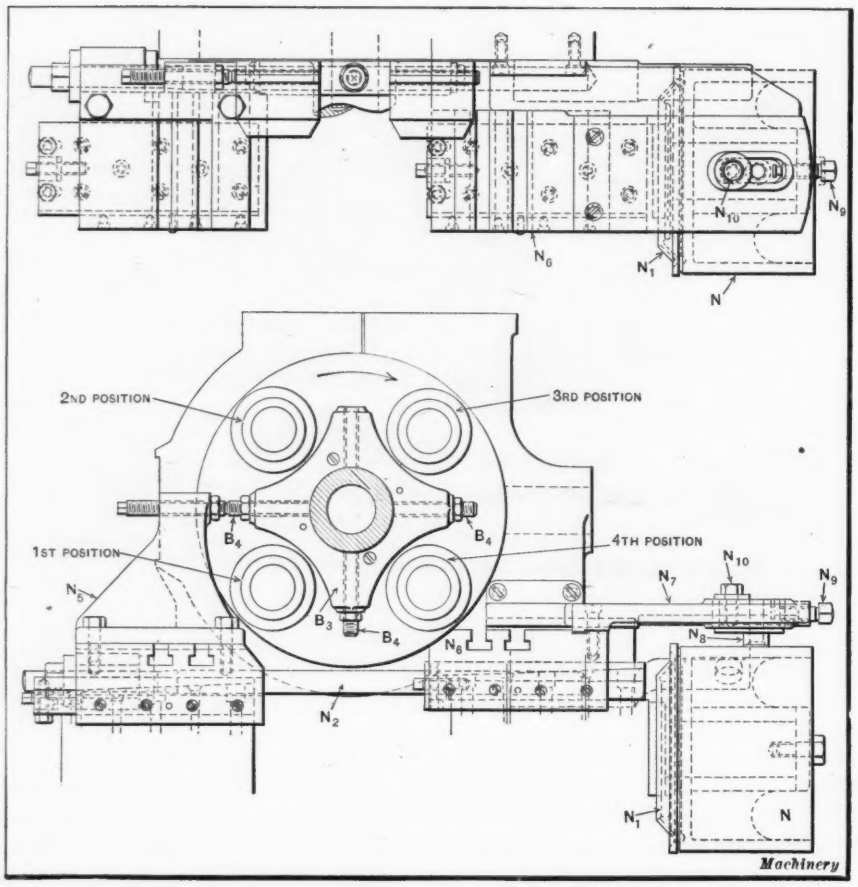


Fig. 32. Diagram illustrating Operation of Forming and Cutting-off Slides

Operating Positions

The Gridley multiple-spindle automatic screw machine has four operating or work-spindle positions as shown in Fig. 32. By arranging the tools on the turret slide, however, as shown in Fig. 26, it is possible to locate one tool-holder back of another so that turning and drilling operations, spotting, centering, etc., can be accomplished from the same tool position, which greatly increases the productive capacity of the machine, as well as its range of work. The turret slide B, as shown in Fig. 28, is advanced by cam O on drum J and is returned by cam O_1, these cams contacting with roll O_2 held on bracket B_2 attached to slide B.

With regard to the operations performed in the various positions, the fourth position is the stock-feeding as well as the cutting-off position. Operations, such as drilling, spot-

SIZE OF MACH.	A	B	C	D	E	F	G	H	I	J	K	L	M
¾"	14′4"	3′10"	1′9½"	3′	2′4"	3′6"	2′11"	14½"	12"	4½"	15"	4"	3"
1¼"	16′	4′4½"	2′1"	3′7½"	2′5¼"	3′6"	2′11"	14½"	12"	4½"	16"	4"	3½"
1¾"	19′5⅞"	6′8⅛"	2′9"	4′1"	2′6½"	3′6"	3′	14½"	12"	5"	18"	6"	5"
2¼"	18′11"	6′6½"	2′9"	4′5"	2′8"	3′6"	3′	14½"	12"	5"	18"	6"	5"

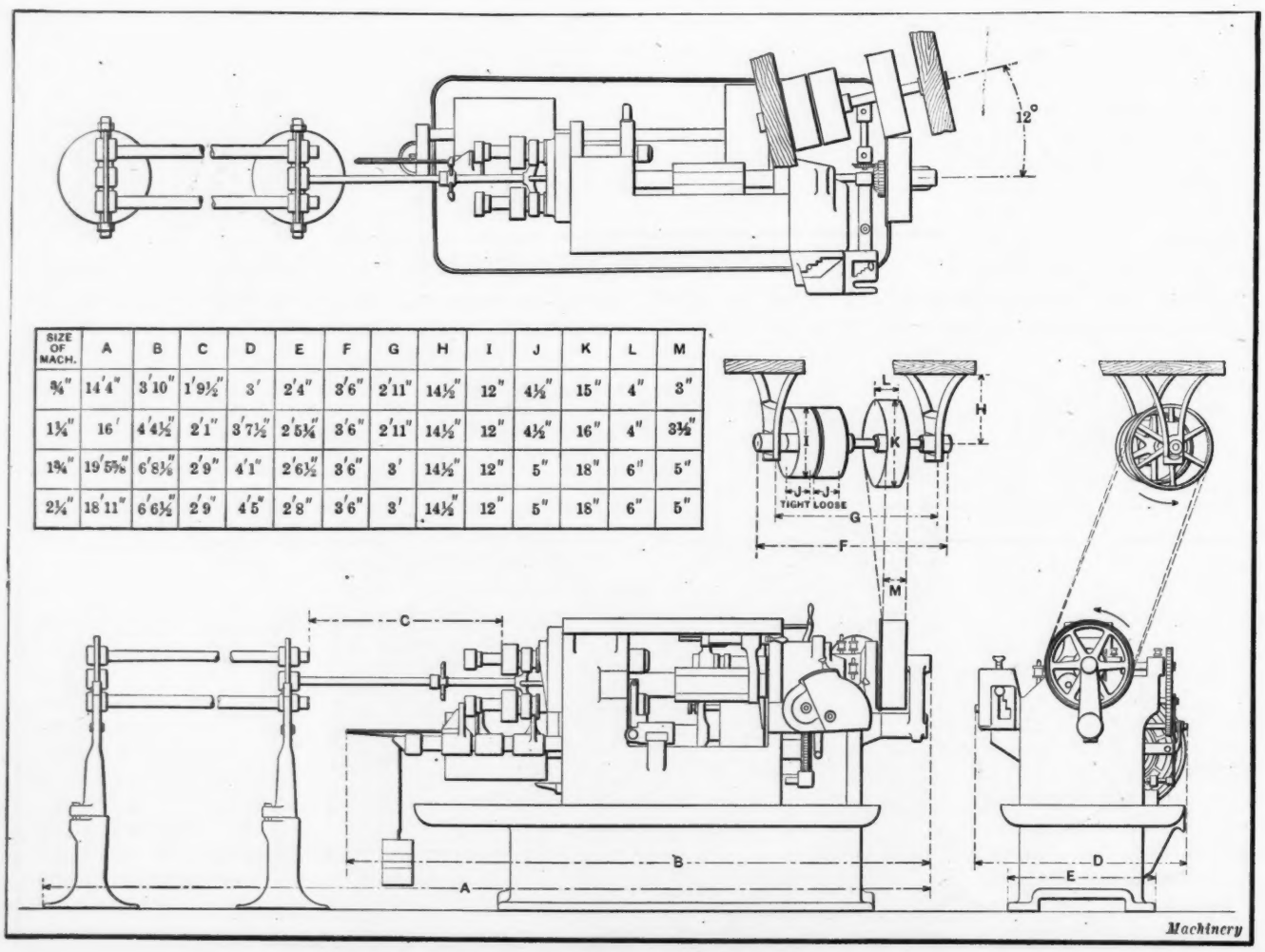


Fig. 33. Setting-up Plan and Overhead Works for Gridley Multiple-spindle Automatic Screw Machine

ting, turning, forming, etc., can be performed in the first position; the second position is similar; whereas the third position is always for threading, the operation here being handled by the die-slide; if the work does not require threading other tools can, of course, be used in this position, the same as in the other positions. As shown in Fig. 27, the forming slide can be provided with a double tool-holder, so that forming can be accomplished either in the first or second position. This arrangement is especially advantageous when there is considerable heavy forming to be done, and roughing and finishing cuts are necessary.

TABLE 1. DATA ON TURRET SLIDE, STOCK FEEDING, FORMING AND CUTTING-OFF SLIDE CAMS

Size of Machine	Throw of Turret Operating Cam, Inches	Turning Cut of Turret Slide, Inches	Stock Feed, Inches	Throw of Forming Cam, Inches	Throw of Cut-off Cam, Inches
3/4	1 1/2	.....	.....	.....	.....
	3	4 1/4	5 1/2	3/8	7/16
	4 9/16	.....	.....	.....	.....
1 1/4	2	.....	.....	.....	.....
	4	5 1/2	6 1/2	0.727	0.809
	6	.....	.....	.....	.....
1 3/4	2 1/2	.....	.....	.....	.....
	5	7	8	3/4	15/16
	7 1/2	.....	.....	.....	.....
2 1/4	2 1/2	.....	.....	.....	.....
	5	7	8	1	1 1/8
	7 1/2	.....	.....	.....	.....

Machinery

Camming for Turret Drum for Fourth Position

It is sometimes necessary to use the fourth position for operating the end-working tool, and in this case a special stop is required, as previously described, as well as a special arrangement of the cams on drum *J*, Fig. 28; this arrangement is shown diagrammatically in Fig. 31. The necessary changes in the cams consist in cutting off the lead cam *O* and setting forward the return cam O_1, so as to return the turret slide *B*, before the piece in the fourth-position work-spindle is cut off. For the 3/4-inch machine, the travel of the turret slide is 2 7/16 inches as shown at *D*. As has been previously mentioned, the stop E_4 shown in Figs. 11 and 12 in the June number is used. The slot in this stop is made to clear the tool used in the fourth position, and to allow the cutting-off slide to recede the required amount. This stop then acts as a stripper in case the lead cam is made so as to have the work cut off while the drill is still in it. When the turret slide recedes, the stop acts as a stripper to remove the work from the tool. When the cutting-off slide is returned, the end of the special stop acts as a stop for the stock.

Application of Motor Drive to Gridley Multiple-spindle Automatic Screw Machine

As the Gridley multiple-spindle automatic screw machines are provided with a single driving pulley that runs at a constant speed, the additions necessary to attach a motor drive are few and simple. Fig. 29 shows a rear view of the Gridley 1¼-inch multiple-spindle automatic, and illustrates the changes made to convert it from belt to motor drive. It will be seen that this consists of the addition of two brackets, which are fastened to the base of the machine and carry a shaft geared to the constant-speed motor shown. The other end of the

TABLE 2. WORK-SPINDLE SPEEDS, DRIVING GEARS, AND SURFACE SPEED OF STOCK FOR GRIDLEY 3/4-INCH MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

Spindle	Pulley Gear		Driving Gear		Diameter of Stock, Inches								
					1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4
R.P.M.	Number of Teeth	Outside Diameter	Number of Teeth	Outside Diameter	Surface Speed, Feet per Minute								
181	20	2¾	44	5¾	11.8	14.8	17.7	20.7	23.7	26.6	29.6	32.5	35.5
209	22	3	42	5½	13.7	17.0	20.5	23.9	27.3	30.7	34.0	37.6	41.0
240	24	3¼	40	5¼	15.7	19.6	23.5	27.5	31.4	35.3	39.2	43.2	47.1
291	27	3⅝	37	4⅞	19.0	23.8	28.5	33.2	38.0	42.8	47.6	52.3	57.1
331	29	3⅞	35	4⅝	21.6	27.0	32.5	37.9	43.2	48.7	54.1	59.5	65.0
375	31	4⅛	33	4⅜	24.5	30.7	36.8	42.9	49.0	55.2	61.3	67.5	73.6
425	33	4⅜	31	4⅛	27.8	34.7	41.7	48.7	55.6	62.6	69.5	76.5	83.4
482	35	4⅝	29	3⅞	31.5	39.4	47.3	55.2	63.0	70.8	78.8	86.7	94.6
548	37	4⅞	27	3⅝	35.8	44.8	53.8	62.7	71.7	80.7	89.6	98.6	107.6
666	40	5¼	24	3¼	43.6	54.5	65.4	76.3	87.1	98.0	108.9	119.8	130.7
763	42	5½	22	3	49.9	62.4	74.9	87.4	99.8	112.4	124.8	137.3	149.8
880	44	5¾	20	2¾	57.6	72.0	86.4	100.8	115.2	129.6	144.0	158.3	172.8

Machinery

Speed of driving pulley, 400 R.P.M. Speed of countershaft, 390 R.P.M. Threading speed, fast, one-third spindle speed. Threading speed, slow, one-fifth spindle speed.

TABLE 3. WORK-SPINDLE SPEEDS, DRIVING GEARS AND SURFACE SPEED OF STOCK FOR GRIDLEY 1 1/4-INCH MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

Spindle	Pulley Gear		Driving Gear		Diameter of Stock, Inches											
					1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1	1 1/16	1 1/8	1 3/16	1 1/4
R.P.M.	Number of Teeth	Outside Diam.	Number of Teeth	Outside Diam.	Surface Speed, Feet per Minute												
207	30	4	58	7½	27.0	30.5	33.9	37.2	40.6	44.0	47.4	50.7	54.2	57.5	61.0	64.3	67.9
229	32	4¼	56	7¼	30.0	33.7	37.5	41.2	44.9	48.7	52.4	56.1	59.9	63.7	67.4	71.2	74.9
252	34	4½	54	7	33.0	37.1	41.2	45.3	49.4	53.6	57.7	61.8	66.0	70.1	74.2	78.3	82.4
276	36	4¾	52	6¾	36.1	40.6	45.1	49.6	54.2	58.7	63.2	67.8	72.2	76.7	81.3	85.8	90.3
304	38	5	50	6½	39.8	44.8	49.7	54.7	59.7	64.7	69.6	74.5	79.6	84.5	89.5	94.5	99.5
333	40	5¼	48	6¼	43.6	49.0	54.5	59.9	65.4	70.8	76.2	81.6	87.2	92.6	98.1	103.5	108.9
365	42	5½	46	6	47.8	53.7	59.7	65.7	71.6	77.6	83.6	89.5	95.5	101.5	107.5	113.5	119.4
400	44	5¾	44	5¾	52.3	58.9	65.4	71.9	78.5	85.1	91.6	98.1	104.7	111.2	117.8	124.3	130.8

Machinery

Speed of driving pulley and countershaft, 400 R.P.M. Threading speed, fast, one-third spindle speed. Threading speed, slow, one-fifth spindle speed.

TABLE 4. WORK-SPINDLE SPEEDS, DRIVING GEARS AND SURFACE SPEED OF STOCK FOR GRIDLEY 1 3/4-INCH MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

Spindle	Pulley Gear		Driving Gear		Diameter of Stock, Inches								
					¾	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1¾
R.P.M.	Number of Teeth	Outside Diameter	Number of Teeth	Outside Diameter	Surface Speed, Feet per Minute								
115.9	22	3	74	9½	22.76	26.55	30.34	34.16	37.93	41.72	45.51	49.31	53.10
130.0	24	3¼	72	9¼	25.53	29.78	34.03	38.29	42.54	46.80	51.05	55.31	59.56
144.85	26	3½	70	9	28.44	33.18	37.92	42.66	47.40	52.14	56.88	61.62	63.36
160.6	28	3¾	68	8¾	31.53	36.79	42.05	47.30	52.56	57.81	63.07	68.32	73.57
177.3	30	4	66	8½	34.81	40.61	46.42	52.22	58.02	63.82	69.63	75.43	81.23
195.0	32	4¼	64	8¼	38.29	44.67	51.05	57.43	63.81	70.20	76.58	82.96	89.34
213.8	34	4½	62	8	41.98	48.98	55.97	62.97	69.97	76.96	83.96	90.96	97.95
234.0	36	4¾	60	7¾	45.90	53.60	61.26	68.92	76.58	84.23	91.89	99.56	107.20
255.5	38	5	58	7½	50.20	58.53	66.89	75.25	83.61	91.97	100.33	108.7	117.06
278.57	40	5¼	56	7¼	54.70	63.81	72.93	82.05	91.16	100.28	109.39	118.51	127.63
303.33	42	5½	54	7	59.56	69.49	79.41	89.34	99.26	109.19	119.12	129.04	138.97
330.0	44	5¾	52	6¾	64.80	75.59	86.39	97.19	107.99	118.79	129.59	140.39	151.19

Machinery

Speed of driving pulley and countershaft, 390 R.P.M. Threading speed, fast, one-third spindle speed. Threading speed, slow, one-fifth spindle speed.

shaft carries a pulley that drives the constant-speed pulley on the machine by a belt.

Drums, Cams, Etc.

There are three cam drums on the Gridley multiple-spindle automatic screw machine; these have been described in detail in connection with the chuck-closing and stock-feeding mechansim, operation of the turret slide and forming and cutting-off slides. The various cams used are grouped in Fig. 30, in which *A*, *B*, B_1, *C* and C_1 are the five cams for advancing the turret slide; *D* is the turret slide return cam; *E* is the safety cam; *F* and *G* are for advancing the cut-off slide and forming slide, respectively; *H* is for returning the cut-off and forming slides; *I* is the right-hand threading cam; *K* is the left-hand threading cam; *L* is the threading advancing cam; *J* is the threading return cam; *M* is the chuck opening cam; *Q* is the chuck closing cam; *R* is the safety cam; *M*, *N*, *O* and *P* are for advancing and returning the pusher tube; *S* is the

TABLE 5. WORK-SPINDLE SPEEDS, DRIVING GEARS AND SURFACE SPEED OF STOCK FOR GRIDLEY 2 1/4-INCH MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

Spindle	Pulley Gear		Driving Gear		Diameter of Stock, Inches					
					1	1¼	1½	1¾	2	2¼
R.P.M.	Number of Teeth	Outside Diameter	Number of Teeth	Outside Diameter	Surface Speed, Feet per Minute					
79	25	3⅜	81	10⅜	20.6	25.9	31.0	36.1	41.3	46.6
92	28	3¾	78	10	24.0	30.1	36.1	42.1	48.1	54.0
106	31	4⅛	75	9⅝	27.7	34.4	41.6	48.5	55.3	62.4
121	34	4½	72	9¼	31.6	40.6	50.6	55.3	63.1	71.0
137	37	4⅞	69	8⅞	34.8	44.8	54.0	62.6	70.3	80.3
155	40	5¼	66	8½	40.6	50.6	60.8	70.9	81.0	90.9
168	42	5½	64	8¼	43.9	54.8	65.8	76.8	87.4	98.8
188	45	5⅞	61	7⅞	49.4	61.7	73.8	86.4	99.0	111.0
211	48	6¼	58	7½	55.3	69.4	83.2	97.1	111.0	124.8
228	50	6½	56	7¼	59.6	75.0	89.9	104.8	119.5	134.0
246	52	6¾	54	7	64.4	80.9	97.3	113.2	129.2	144.9
265	54	7	52	6¾	69.2	87.0	104.5	121.4	139.4	156.1
287	56	7¼	50	6½	75.0	94.0	112.6	131.5	150.0	159.0
310	58	7½	48	6¼	80.8	101.4	121.2	141.9	161.6	182.6
347	61	7⅞	45	5⅞	90.8	113.6	136.2	158.9	181.6	204.4
390	64	8¼	42	5½	102.0	127.8	152.8	178.6	204.0	229.7

Machinery

TABLE 6. PRINCIPAL DIMENSIONS AND CAPACITIES OF GRIDLEY AUTOMATIC SCREW MACHINES

Standard Size Machine	¾	1¼	1¾	2¼
Capacity of Chuck, Round Stock, Inches	3/4	1 1/4	1 3/4	2 1/4
Capacity of Chuck, Square Stock, Inches	0.530	0.8838	1.237	1.591
Capacity of Chuck, Hexagon Stock, Inches	0.649	1.082	1.515	1.948
Maximum Length of Feed, Inches	5 1/2	6 1/2	8	8
Maximum Length of Turning Operation, Inches	4 1/2	5 1/2	7	7
Speed of Countershaft, R.P.M.	390	400	390	390
Speed of Driving Pulley, R.P.M	400	400	390	390
Diameter of Driving Pulley, Inches	14 1/2	16	18	18
Width of Belt for Countershaft, Inches	4	4	6	6
Width of Belt for Spindle Shaft, Inches	3	3 1/2	5	5
Threading Speed compared with Spindle Speed, Fast	1/3	1/3	1/3	1/3
Threading Speed compared with Spindle Speed, Slow	1/5	1/5	1/5	1/5
Size of Lead Cams, Inches	1/2, 3, 4, 9/16	2, 4, 6	2 1/2, 5, 7 1/2	2 1/2, 5, 7 1/2
Size of Forming Cam, Inches	3/8	0.727	3/4	1
Size of Cut-off Cam, Inches	7/16	0.809	15/16	1 1/8
Floor Space over all, including Reel Stand	14′, 4″, by 3′	16′ by 3′, 7 1/2″	19′ 6″, by 4′, 1″	18′, 11″ by 4′, 5″

Machinery

cam for withdrawing the locking pin; *T* is for advancing the stop; *U* and *V* are the cams for the fast and slow speeds.

As has been previously mentioned, the turret slide operating cams are supplied in three different throws with each size of machine, whereas the forming and cutting-off cams are supplied in one throw for each size of machine. The cam data on the various sizes of machines are given in Table 1. The cams listed are those furnished with the machine, and it is evident, of course, that it would be necessary in some cases to use special cams when the work to be accomplished is out of the ordinary line.

Change-gears, Spindle Speeds and Surface Speeds

Tables 2 to 5, inclusive, give the data regarding the change-gears used on the various sizes of machines for securing a suitable spindle speed for the work being machined. The right-hand section of these tables includes the surface speed of the stock within the capacity of the machines, obtainable with the change-gears supplied.

Principal Dimensions and Capacities

The table accompanying Fig. 33, and Table 6, include the principal dimensions such as chuck capacities, countershaft speeds, diameters of pulleys, over-all dimensions, etc.

* * *

CHUCK FOR HOLDING DRIVING-BOXES

BY M. K.

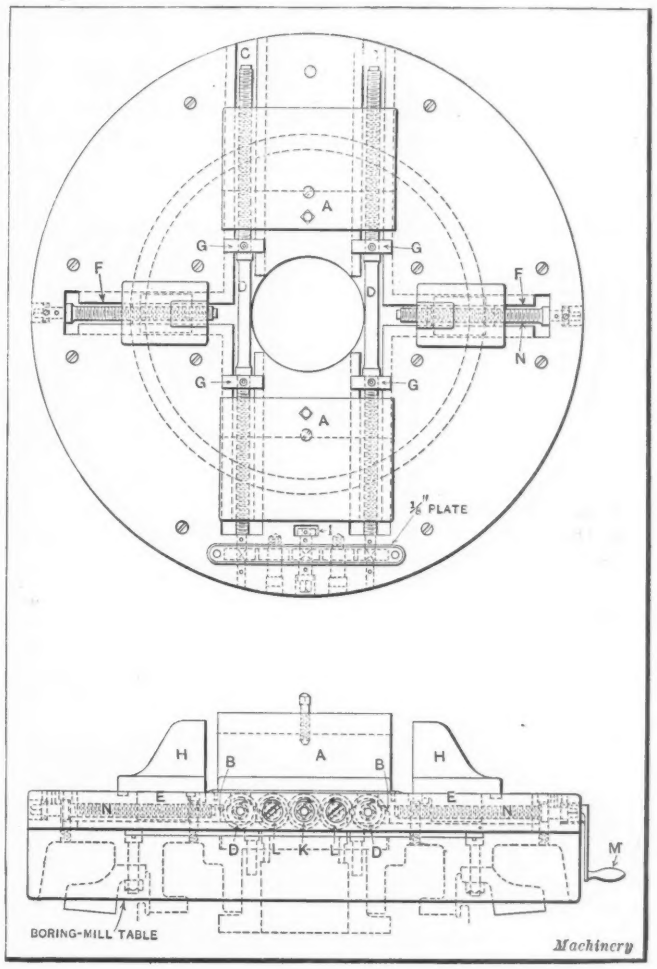
In the accompanying illustration is shown a specially designed chuck for holding driving-boxes while boring on a boring mill. The base is a solid cast-iron piece 3⅝ inches thick, with a ring protruding ½ inch. This ring, the width of which is 1½ inch and the outside diameter 35 inches, fits in a groove cut in the table of the boring mill. As the diameters of the boring mill table and the base of the chuck are the same—4½ feet—the chuck presents a neat and uniform appearance.

The chuck is fastened to the boring mill table by screws. The platen has an 11¼-inch hole in the center for the chips to drop into; this also allows the boring-bar and tool to clear. The two main sliding jaws *A* of the chuck are moved together, and hold the sides of the driving-box that go next to the driving-box shoes. These two jaws have projections *B* that fit corresponding slots *C* planed in the bed-plate. These projections are 4 inches wide and 1 inch high, and are beveled at a 30-degree angle to a width of 2 inches. One jaw is tapped right hand and the other left hand to suit the screws *D*. These screws have 2¼ inches more thread on one end than on the other, so care must be taken to see that just this much of each screw is screwed into the block having the right-hand threads before the block having the left-hand threads is brought up against the thread on the other end of the rod. As the screw is turned, both jaws are moved toward or away from each other. Before adjusting jaws *A*, two blocks *E* must be put in place in the slots *F* planed in the table at right angles to the slots *C*. One of these blocks is tapped right hand and the other left hand, and each may be moved independently of the other. After jaws *A* are put in place, four blocks *G* are inserted in small slots cut across slots *C*; these blocks hold screws *D* in place on the table. After the screws in slots *F* are screwed into blocks *H*, a locking washer with a 5/16-inch set-screw is put in place to hold them in position.

On the front, where the main adjustment is made by the operator, five holes are drilled. The middle one is drilled to slot *I*, in which is placed the washer that holds screw *K* in place. A gear turning on this screw *K* turns gears *L*, which turn the wheels on the long screw rods *D*, so that by turning the center screw *K* with a wrought-iron wrench *M*, every gear is turned, as they are connected, and consequently the long screw rods are turned, thus moving the two large jaws together, either in or out, as the case may be. When all the gears are in place, a wrought-iron plate with bevel edge is fastened over them as a gear guard.

The blocks *H* are removable in order that the driving-box may be put on or taken off the chuck and are just set in. They are kept in place by the lug on blocks *E*, but can easily be removed by loosening screws *N*, as they are 6 inches between their lugs and the screw blocks *E* are only 5⅝ inches long. It is usually necessary to remove only one of these blocks when a box is to be put on or taken off. The base is cast iron, the jaws are steel castings, and the gears, pins, screw rods and blocks are of soft axle steel.

The box is held in place and central with the sides, so that it can be so bored, because of the right-hand and left-hand threads on the screws *D* passing through the large jaws *A*. The two smaller jaws *H* are for adjusting the box the other way, namely, to bore more or less out of the part of the shell that rests on the axle, as is desired. These smaller jaws are independent of each other, and when the box is in the proper location, all the jaws are tightened, and the set-screws in the large jaws are tightened. To pull the box loose from the machine would take about as much energy as would be required to pull the machine off its heavy foundation. With this chuck the cost of boring boxes can be greatly reduced, as it holds the box when the heaviest cuts are taken.



Construction of Chuck for holding Driving-boxes

* * *

The National Board of Fire Underwriters points to the experience of the Copley Cement Mfg. Co., Allentown, Pa., as illustrating the danger of using untested hose. A fire was discovered in a stone bunker in the plant, started presumably from a locomotive spark. The bunker was of slow-burning construction, the fire was quickly detected, and the mill fire squad responded promptly, so that there should have been little loss. The fire squad attached a coupling to a new fire hose, ran it to the blaze and turned on the water. The hose burst in five or six places, and a new length was substituted which failed in the same way. Thus the fire had made considerable headway before it was possible to obtain an effective stream. The loss amounted to $7000, which was almost entirely due to the failure of the hose. Hose tested by the National Board of Fire Underwriters is subjected to 300 pounds pressure, and each length that has successfully withstood this test bears the Underwriter's label.

SCHEMES THAT DIDN'T WORK

FAULTS IN MACHINE DESIGNS AND SUGGESTED IMPROVEMENTS

BY F. B. JACOBS [1]

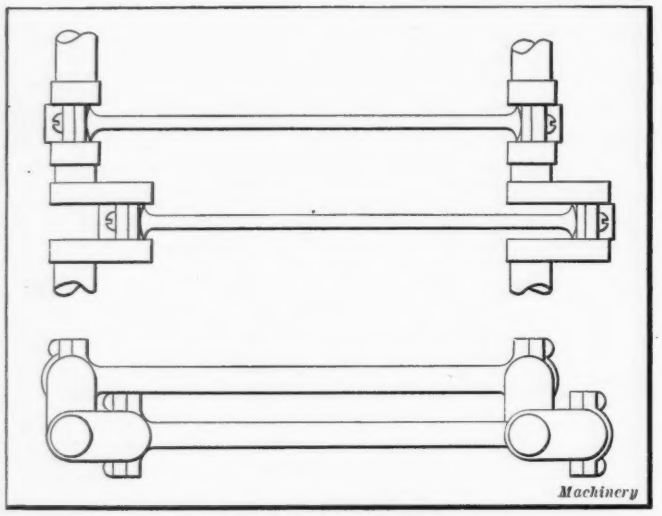


Fig. 1. Double Connecting-rod Drive

THE average all-around machinist who has been employed on experimental work to any extent can recall numerous instances wherein the carefully laid plans of the inventor and designer have fallen short of expectations. A drawing of a new machine, no matter how carefully executed, is theory, pure and simple—a child of the inventor's brain, as it were. Until practical results have taken form in the shape of the finished machine, no one, no matter how well versed in theory, can be certain of the actual results. When a finished machine does not come up to the originator's expectations, it is a pretty good sign that simple mechanical principles have been overlooked; for while many ideas look well on paper, they do not work out in practice. Those who read technical papers have ample opportunity to familiarize themselves with correct mechanical details; so, for a change, it may do no harm to analyze a few brief details that fell short of the originator's expectations.

In cases where it is necessary to operate two rapidly revolving shafts in the same direction, one driving the other, it is common practice, among manufacturers of certain kinds of sewing machines, to use the double connecting-rod drive illustrated in Fig. 1. As the cranks on the shafts are set at 90 degrees, one rod pulls the other over the dead center. This mechanism gives a positive, noiseless drive at especially high speeds, so it is often preferred to bevel gearing or other means of transmitting the necessary motion.

A prominent Eastern manufacturer wished to utilize this principle, but considered the cost of the two crankshafts prohibitive; so he attempted to use two straight shafts connected with eccentrics, as shown in Fig. 2. The plan failed utterly, as any mechanic ought to see at the first glance. While an eccentric is an excellent means for converting rotary motion into reciprocating motion, as in the valve gear of an ordinary steam engine, it is a very poor way in which to try to convert reciprocating motion into rotary motion, which was what was attempted in using an eccentric and strap for turning a shaft. One set of eccentrics would pull the other set off center, when both shafts were turned by hand in the same direction, but otherwise practical results were impossible owing to the friction between the eccentrics and their straps. This will be readily understood when we consider that an eccentric is nothing more nor less than a greatly enlarged crankpin. Notwithstanding the fact that the straps fitted the eccentrics freely enough to make a running fit and that the rods were adjustable to give the correct center distances which, of course, was necessary, one shaft absolutely failed to turn the other by the slightest fraction of a revolution.

Designs Having Poor Lever Arrangements

In Fig. 3 is shown a feeding mechanism used on a semi-automatic press for fastening thin sheet-metal caps on round-headed steel rivets. Sixteen dies were set in a revolving cast-iron disk that was rotated by a ratchet and pawl through the medium of a lever. To prevent overfeeding, due to the momentum that the disk might develop, a slight friction was provided by means of a large nut and fiber washer. A trial of the machine showed that something was radically wrong because the disk failed to stop at just the right station, which, of course, spoiled the alignment between the dies and the single punch that worked in connection with them. At first glance the lever appears to be of the correct design, as it is of the well-known second class; that is, a lever with the weight or converted motion between the fulcrum and the point of applied power. A careful inspection showed that the ratchet was accurately cut and that the holes were correctly spaced. If the designer had given a little more thought to the problem when he made his lay-out, he would have seen where the trouble lay. The radial distance at the actual point of converted motion, that is, at the dies themselves, is much greater than the periphery of the ratchet, and as the amount of friction on the bottom of the disk was greater at its periphery than at an imaginary circle under the periphery of the ratchet, an unnecessary amount of force

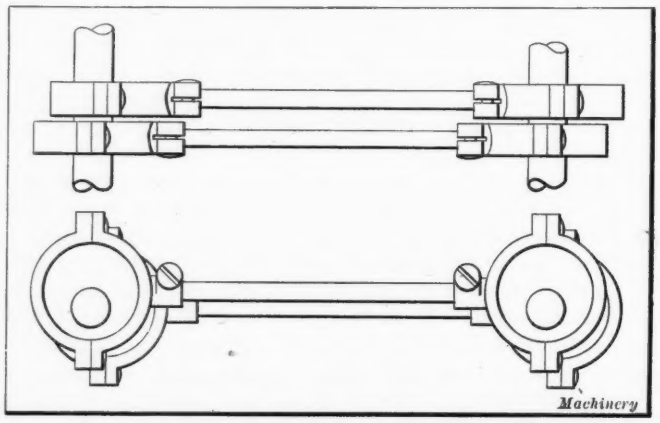


Fig. 2. Eccentrics used with Double Connecting-rod Drive

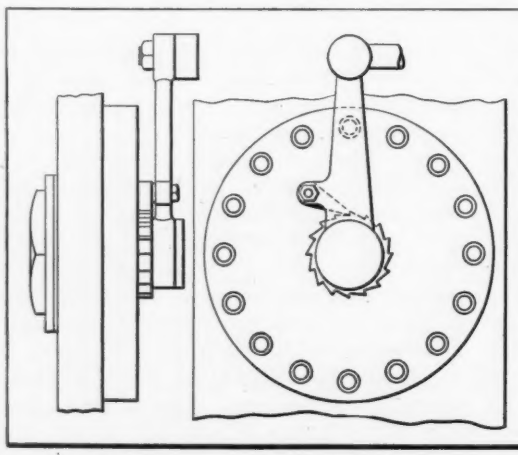


Fig. 3. Feeding Mechanism on Semi-automatic Press for fastening Metal Caps on Steel Rivets

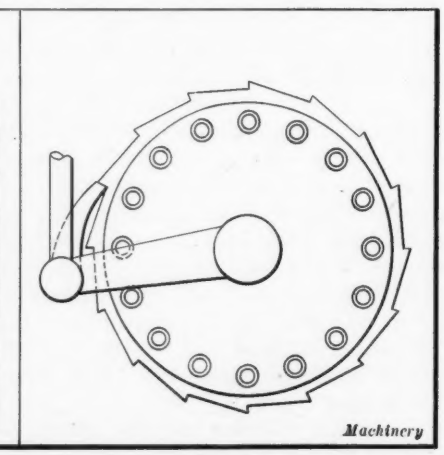


Fig. 4. Corrected Design of Feeding Mechanism shown in Fig. 3

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was required to turn the disk. This resulted in a certain amount of springing motion in all the parts actuating the disk, which accounted for the error in spacing. The difficulty was entirely overcome by redesigning the feeding mechanism as shown in Fig. 4. Here a large ratchet is placed over the outside of the disk and the pawl is of more substantial construction. The lever is still of the second class; and as the point of applied force is outside the radius of greatest friction, there is not as much chance for inaccurate spacing to develop. As a matter of fact, the machine in question worked very satisfactorily after this simple change was made.

Another simple leverage problem was easily solved by the proprietor of a small shop through the application of a correct principle. He was called upon to repair the valve gear of a high-speed, Corliss engine that persisted in heating its eccentric to an alarming degree. The lay-out of this particular valve gear is shown in the upper view of Fig. 5, where *A* is the eccentric, *B* the rocker, and *C* the wrist-plate. As the wrist-plate and main shaft are in the same plane, the designer could not resist the temptation to employ the principle of the third-class lever, that is, one with the point of applied force between the fulcrum and weight, and thus make the eccentric and reach-rods work in as nearly horizontal lines as possible. In this case, however, it was necessary to actuate a valve gear weighing several tons, 200 times per minute, as the engine ran at a speed of 100 revolutions per minute. Besides, the dash-pots were six inches in diameter, which necessitated overcoming a resistance of 415.6278 pounds, due to atmospheric pressure, 200 times every minute. Quick-acting dash-pots are necessary on a high-speed engine of the

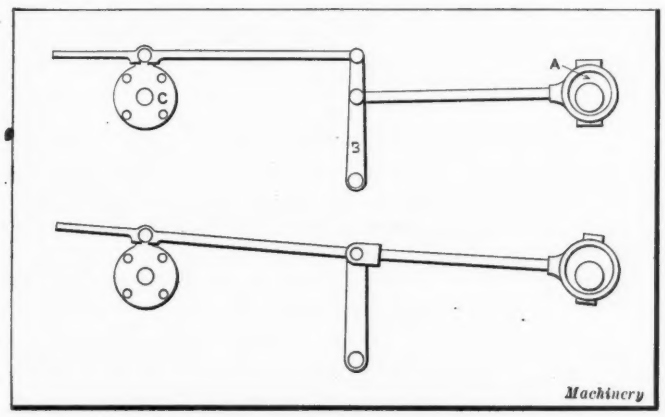

Fig. 5. Faulty and Correctly Designed Valve Gear

Corliss type, as the comparatively long stroke necessitates closing the valves with lightning-like rapidity the instant the crab claws release the valve stems.

The man who undertook to remedy the difficulty of overheating ascertained that the trouble started a few weeks previous, after the engine had been speeded up some twenty-five revolutions per minute. In the lower view of Fig. 5 is shown the method of overcoming the trouble. The eccentric was given a greater stroke so that it would move the wrist-plate the required number of degrees without multiplication of the stroke by the rocker arm. The rocker was shortened to bring the main shaft in line with the wrist-plate pin; and the end of the eccentric rod was provided with a yoke for carrying the pin that pivoted it to the rocker and reach-rod. The third-class lever gives a greater movement to the actuated part than is given by the driving unit. Every mechanic is aware that it takes force to multiply leverage, and here the force was developed at the expense of friction. The engine ran all right at its original speed, but the increased speed offered too much resistance (as the rocking parts reversed) for the eccentric to take care of without heating.

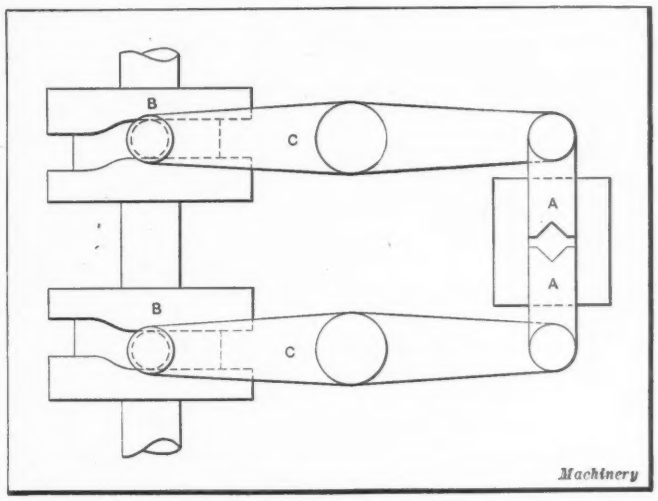

Fig. 8. Poor Lever Arrangement

Friction Drives

Some years ago the proprietor of a small shop desired to perfect a variable-speed friction drive. His idea is shown in Fig. 6. A shaft *A*, rotating as shown by the arrow, was supposed to drive the friction wheel *B*. The shaft *C* that carries the friction wheel is provided with means for moving it toward or away from the driving shaft *A*. The two large friction disks *D* are made to grip the friction wheel *B* by means of a heavy spring *E*. The ball thrust *F* is to reduce the friction caused by the spring pressure as much as possible. We all know how easy it is to roll a pencil between the fingers of both hands and the "boss" had this principle in mind when he designed the drive in question. But it refused to work. He tried cast-iron disks with a fiber friction wheel, fiber-faced disks with a cast-iron friction wheel, aluminum disks with a wooden friction wheel, and as a last resort he knurled the faces of the disks, hoping to coax them to drive a leather friction wheel. All these experiments were fruitless.

But before trying to ascertain why the drive refused to work it may be well to consider a friction drive that does work and then compare the two. The friction drive illustrated in Fig. 7 has been used successfully instead of the ordinary form of transmission in a light-powered automobile. The motor shaft *A* is fastened to the driving disk *B* and a ball thrust bearing *C* eliminates end thrust. The friction wheel *D* drives the jack-shaft *E* and means are provided for moving it across the face of the wheel to obtain different speeds; the greatest speed is obtained when in the position shown. By moving the friction wheel past the center of the driving disk, the reverse motion is gained. The jack-shaft brings the friction wheel in close contact with the friction disk through the medium of a foot-pedal. All things considered, it is a neat simple device. The friction disk and friction wheel are of the same diameter, so that when transmitting the greatest speed, the speed of the jack-shaft does not exceed that of the engine shaft. To gain power to climb hills the ratio between the engine shaft and jack-shaft is, of course, reduced.

In the device shown in Fig. 6 it was attempted to make the driving shaft drive the driven shaft at a

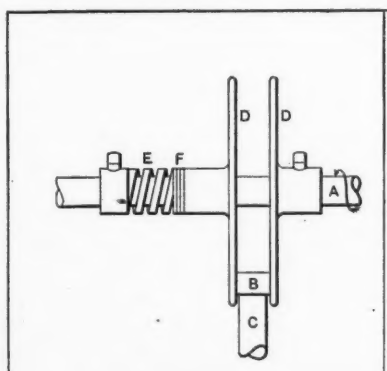

Fig. 6. Variable-speed Friction Drive of Faulty Design

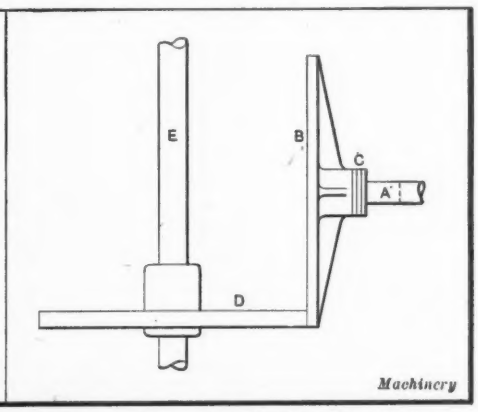

Fig. 7. Improvement on Friction Drive Design shown in Fig. 6

greatly increased speed, to say nothing of also driving another friction wheel in an opposite direction. With the spring adjusted loosely, the coefficient of friction was not great enough to drive the friction wheel; and by compressing the spring to its utmost, the coefficient of friction was too great for the device to overcome. These experiments were, of course, interesting, but after the "boss" had spent several hundred dollars without getting any tangible results he decided that he did not want a friction drive anyway.

Faulty Cam Designs

That we frequently make mistakes in proportioning levers few will dispute; a typical illustration of this is shown in Fig. 8. This illustration represents part of an automatic machine in which the two dies *A* grip the work by the action of the cams *B* working through the medium of levers *C*. Pivoting the levers midway between the cams and points of applied force resulted in a very hard-working motion, as several hundred pounds pressure was required to grip the work. As a result, the strain on the cams caused them to wear out in about two weeks. Fig. 9 illustrates the manner in which the difficulty was overcome. Here the distance from the fulcrum to the point of conveyed motion is considerably less than the distance from the fulcrum to the point of applied force. It was, of course, necessary to increase the stroke of the cams, but as it took less than a third as much force on the part of the cams to grip the work the cam was much longer-lived.

Another interesting cam motion is shown in Fig. 10. This motion is as follows: Starting from the point *A* and traveling clockwise there is first a drop of 1⅜ inch in 90 degrees, then a period of rest of 150 degrees, then a rise of 1⅜ inch in 30 degrees followed by a period of rest of 90 degrees. The cam ran at a speed of 1000 revolutions per minute and it was necessary for the sharp rise of 1⅜ inch to be a uniform motion. Uniform rises are necessary in some cases even though they are hard-working except at slow speeds. In this case, the motion was very hard-working, as an excessive side strain was brought to bear on the cam bar. After several cam bars had been bent, and a pair of spur gears that drove the cam-shaft had been stripped of their teeth, an effort was made to remedy the trouble. It was impossible to alter the design of the cam motion to the extent of dispensing with the cam bar; neither was it possible to do away with the uniform rise and, worst of all, it was not practicable to reduce the speed of the machine.

Fig. 11 shows the method used for overcoming this difficulty. A swinging lever was interposed between the cam and the roll on the cam bar. Thus when the sharp cam rise strikes the roll on the swinging lever, the side strain that came on the cam bar in the previous design is absorbed by the swinging lever in the form of tensional strain. The roll on the swinging lever serves to lift the cam bar under a compression strain only.

The few instances cited are mechanical bulls, and had they been the work of mechanical students instead of hard-headed, dollar-chasing business men we, no doubt, would smile knowingly as we prided ourselves on our superior knowledge of mechanical problems. The mistakes, however, were committed by mechanical men who were supposed to know better. These mistakes are of value, however, as it is through them that we learn by experience, building the successes of today on the ashes of the failures of yesterday.

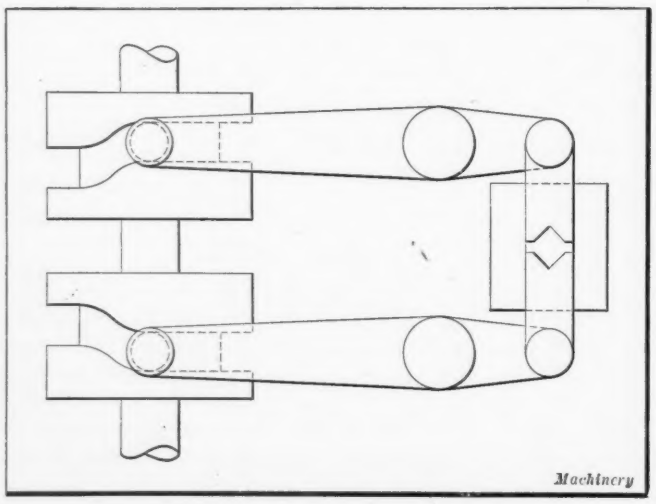

Fig. 9. Correct Arrangement of Levers shown in Fig. 8

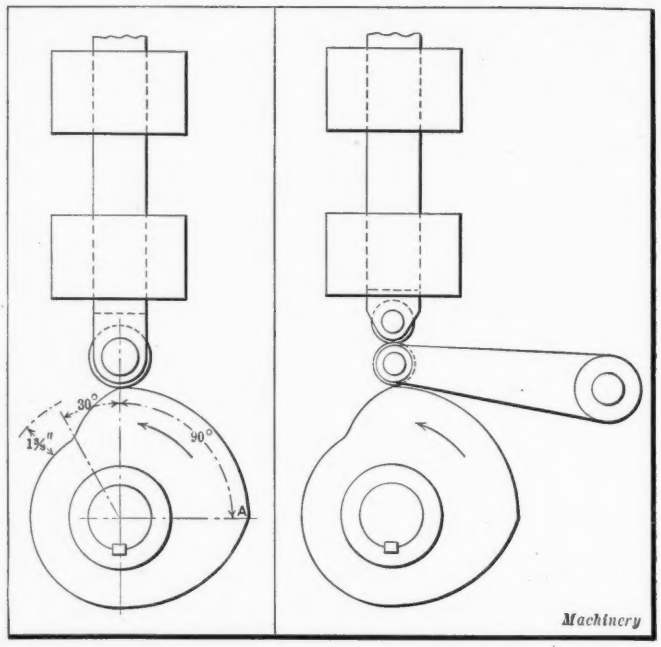

Fig. 10. Cam Arrangement having Excessive Side Strain

Fig. 11. Improvement on Cam Arrangement shown in Fig. 10

* * *

CHARACTERISTICS OF INVAR

The fact that all metals expand and contract more or less with every variation of temperature introduces complications in the making of instruments concerned with absolute standards of time or space. After much research, a nickel-steel alloy, containing about 36 per cent nickel and about 0.5 per cent each of carbon and manganese, was found to have a remarkably small thermal expansion at ordinary temperatures. To this the name "invar" has been given. A summary of the results obtained during the last twenty-five years by various investigators of this property of invar and related nickel steels shows that a bar of ordinary invar expands or contracts about one millionth of its length for each degree alteration in the temperature within the range of 0 to 40 degrees C. A much higher degree of constancy than this, however, is sometimes obtained; much depends on the amount of carbon and manganese present. Small quantities of invar have been manufactured that showed a change in length of less than half a millionth per degree between 0 and 20 degrees C.; this alloy contains 0.06 per cent carbon and 9.39 per cent manganese. Samples have even been prepared that showed a negative coefficient of expansion, contracting slightly instead of expanding as the temperature rose. Invar possesses this peculiar property only with a moderate temperature range. From 40 degrees upward, the coefficient of expansion steadily increases as the temperature rises, until at 200 degrees it is almost the same as that of Bessemer steel. Like certain other alloys, invar gradually elongates with time, so when it is used on a length standard, a periodic correction must be made to allow for this. The effect may be largely diminished, however, by prolonged heat-treatment prior to finishing. M. E.

* * *

Aluminum castings that will take a high polish, according to a paper read by E. A. Barnes before the American Foundrymen's Association, may be made by adding from 8 to 10 per cent of tin to the copper-aluminum mixture. A rich aluminum-copper-tin alloy is made up and cast into bars which are added to the aluminum at the proper time. Castings made of this alloy do not contain the small blue specks that are due to the presence of gas in the metal.

EFFICIENCY OF FORWARD AND REVERSE DRIVES

DETERMINATION OF EFFICIENCY OF WORM-GEARS AND SPUR GEARS BY GRAPHIC METHOD

BY JOHN S. MYERS[1]

IN all mechanical devices for the transmission of energy there is some loss due to friction, the efficiency of the mechanism being the ratio of the energy output to the energy input. It is well known that the efficiency of a device may be fairly high when transmitting energy in one direction and yet quite low when operating inversely. For instance, a small pinion driving a large gear is somewhat more efficient than the same gear driving the pinion. A screw jack is a reasonably efficient means of raising a load, but the load acting against the screw is unable to turn it, for the efficiency in the reverse direction is negative, that is, less than zero. The ordinary non-overhauling worm drive, frequently used for hoisting purposes, and various other so-called self-locking mechanisms are designed upon this principle of negative efficiency for reverse operation. While there is considerable literature on the subject of worm-gearing and its efficiency, the worm is invariably treated as the driver. It is the object of the present article to present a simple graphic method for determining the efficiency of such drives, with either the worm or the worm-wheel the driver, giving formulas and curves that are based on the graphic analysis of the various forces involved.

Worm and Wheel with Worm the Driver

Referring to Fig. 1, triangle ABC represents the worm in static equilibrium, while triangle CBI represents a similar state for the worm-wheel. $P(=AB)$ represents the rotative force acting at the pitch diameter of the worm, that is, the driving force; $T(=CB)$ is the component of P that acts normal to the worm-wheel teeth; $R(=AC)$ is the component of P that acts against the thrust washers; $F(=IB)$ is the component of T that acts as a tangential effort on the worm-wheel teeth; $H(=CI)$ is the component of T that acts on the worm-wheel hub.

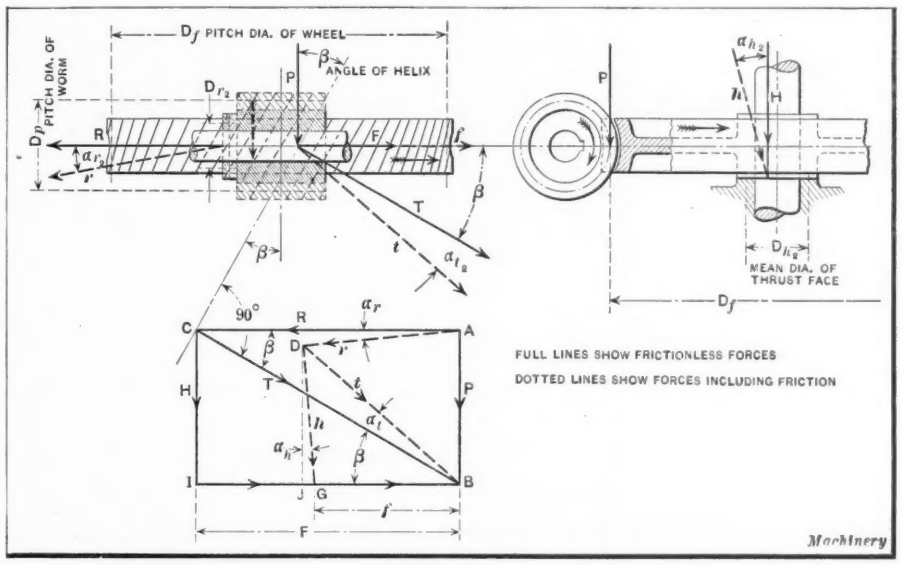

Fig. 1. Forces acting on Worm and Worm-wheel when Worm is Driver

When in motion, in order that the surfaces may slide upon each other, the forces acting on these surfaces make an angle with the normal such that the tangent of the angle is equal to the coefficient of friction. Triangle ABD represents the forces acting on the worm, and triangle DBG those acting on the worm-wheel when in motion. $t(=DB)$ is the tooth load; $r(=AD)$, the force on the thrust bearing; $h(=DG)$, the force on the worm-wheel hub; and $f(=GB)$ is the effective tangential force on the worm-wheel teeth.

As F is the force on the worm-wheel teeth necessary for static equilibrium if there were no friction, and f is the effective effort taking into account the friction, the efficiency E_p may be expressed as:

$$E_p = \frac{f}{F} \qquad (1)$$

The sub letter $_p$ designates the force P at the worm as the driving force.

In laying out the resolution of forces, the angles in the diagram are made such that their frictional components are reduced to their equivalent values at the pitch line.

Let C_{t_2} = coefficient of friction at teeth;
C_{r_2} = coefficient of friction at thrust bearing;
C_{h_2} = coefficient of friction at hub of wheel;
C_t = effective value of C_{t_2} at pitch line;
C_r = effective value of C_{r_2} at pitch line;
C_h = effective value of C_{h_2} at pitch line;
α_t = effective value of angle α_{t_2} at the pitch line;
α_r = effective value of angle α_{r_2} at the pitch line;
α_h = effective value of angle α_{h_2} at the pitch line;

The effective values are:

$$\text{Tan } \alpha_r = C_r = C_{r_2}\frac{D_{r_2}}{D_p} \qquad (2)$$

$$\text{Tan } \alpha_h = C_h = C_{h_2}\frac{D_{h_2}}{D_f} \qquad (3)$$

C_{t_2} acts directly at the pitch line; hence:

$$C_t = C_{t_2},\ \alpha_t = \alpha_{t_2}, \text{ and tan } \alpha_t = C_{t_2} = C_t \qquad (4)$$

For D_{r_2}, D_p, D_{h_2} and D_f, see Fig. 1.

Limiting Conditions

An inspection of Fig. 1 will show that as angle β becomes smaller, the theoretical force F increases much more rapidly than the effective force f, resulting in low efficiency. When $\beta = 0$, F is infinite, while f has a measurable value, and, consequently, the efficiency is zero. This is one limit of the efficiency curve. For large values of angle β the effective force f decreases rapidly, again resulting in low efficiency. When angle JDG = angle JDB, line DG coincides with line DB, $f = 0$, and the efficiency is zero. From the geometry of the figure it can be seen that this condition will exist when $\beta + \alpha_t + \alpha_h = 90$ degrees. The maximum value of the angle β is then:

$$\beta_{max} = 90 - \alpha_t - \alpha_h \qquad (5)$$

For values of β equal to or greater than this the worm cannot drive the worm-wheel; this is the limiting condition for steep-angle worms. It is interesting to note that angle α_r does not appear in Formula (5). An inspection of the diagram will show that, as α_r increases, the value of f, and consequently the efficiency, decreases; but while f decreases, it will not actually become zero until α_r becomes 90 degrees. The significance of this is that, however great may be the friction of the thrust bearing, the device will not lock from this cause alone unless it actually seizes. A roller or ball thrust bearing for the worm will increase the efficiency of a drive that is operative, but it will not prevent a quick angle worm that locked from doing so; the cure for this is a reduction of the friction on the teeth and on the worm-wheel hub.

Formulas for Efficiency with Worm the Driver

For purposes of analysis or comparison with other data, the results of the foregoing graphic method may be expressed by formulas. In Fig. 2, P is the load applied at the pitch line of

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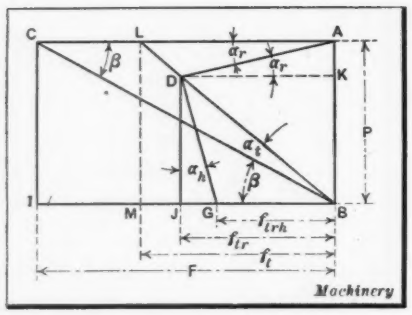


Fig. 2. Diagram used in developing Formulas for Efficiency when Worm is Driver

the worm, BC is the tooth load, and BI its tangential component on the worm-wheel if frictionless. Considering the friction of the teeth only, BL is the tooth load and $BM = f_t$ is the effective tangential component. From the geometry of the figure, $f_t = \frac{P}{\tan(\beta + \alpha_t)}$

and $F = \frac{P}{\tan \beta}$, from which the efficiency is:

$$E_{pt} = \frac{f_t}{F} = \frac{\tan \beta}{\tan(\beta + \alpha_t)} \qquad (6)$$

From general trigonometric formulas:

$$\text{Tan}\,(\beta + \alpha_t) = \frac{\tan \beta + \tan \alpha_t}{1 - \tan \beta \tan \alpha_t}$$

Also, from Formula (4), $\tan \alpha_t = C_t$. Substituting in Formula (6) gives:

$$E_{pt} = \frac{\tan \beta\,(1 - C_t \tan \beta)}{\tan \beta + C_t} \qquad (7)$$

This formula is identical with the formula given by Prof. Barr; it includes the tooth friction only.[1] Taking into account the friction of the worm thrust bearing also, the tooth load is BD and its effective component is $BJ = f_{tr}$. As $BK = JD = f_{tr} \tan(\beta + \alpha_t)$, $KA = f_{tr} \tan \alpha_r$, $F = \frac{P}{\tan \beta}$, and $P = BK + KA$, $f_{tr} = \frac{P}{\tan(\beta + \alpha_t) + \tan \alpha_r}$. The efficiency is then:

$$E_{ptr} = \frac{f_{tr}}{F} = \frac{\tan \beta}{\tan(\beta + \alpha_t) + \tan \alpha_r} \qquad (8)$$

Substituting the value of $\tan(\beta + \alpha_t)$ previously given, together with $\tan \alpha_t = C_t$ and $\tan \alpha_r = C_r$, this reduces to:

$$E_{ptr} = \frac{\tan \beta\,(1 - C_t \tan \beta)}{\tan \beta + C_t + C_r - C_t C_r \tan \beta} \qquad (9)$$

If the friction on the thrust bearing is equal to the friction on the teeth, $C_r = C_t$; and if the term $C_t C_r \tan \beta$, which is small, is dropped, Formula (9) becomes:

$$E_{ptr} = \frac{\tan \beta\,(1 - C_t \tan \beta)}{\tan \beta + 2C_t} \qquad (10)$$

This formula agrees with that given by Prof. Barr for similar conditions. Taking into account the friction of the teeth, of the thrust bearing, and of the worm-wheel hub, the tooth load, as before, is represented by BD. The effective tangential component is now $BG = f_{trh}$. From the geometry of the construction, $JD = BK = f_{tr} \tan(\beta + \alpha_t)$ and $JG = JD \tan \alpha_h$. Substituting the value of JD, $JG = f_{tr} \tan(\beta + \alpha_t) \tan \alpha_h$. Then $f_{trh} = f_{tr} - JG = f_{tr}\,[1 - \tan(\beta + \alpha_t) \tan \alpha_h]$. Substituting the value of f_{tr} previously developed gives:

[1] For simplicity's sake, the fact that the teeth may be of the 15- or 20-degree involute form is in all cases neglected; the treatment is as though the faces of the worm teeth were radial. The error involved is small as far as efficiency is concerned.

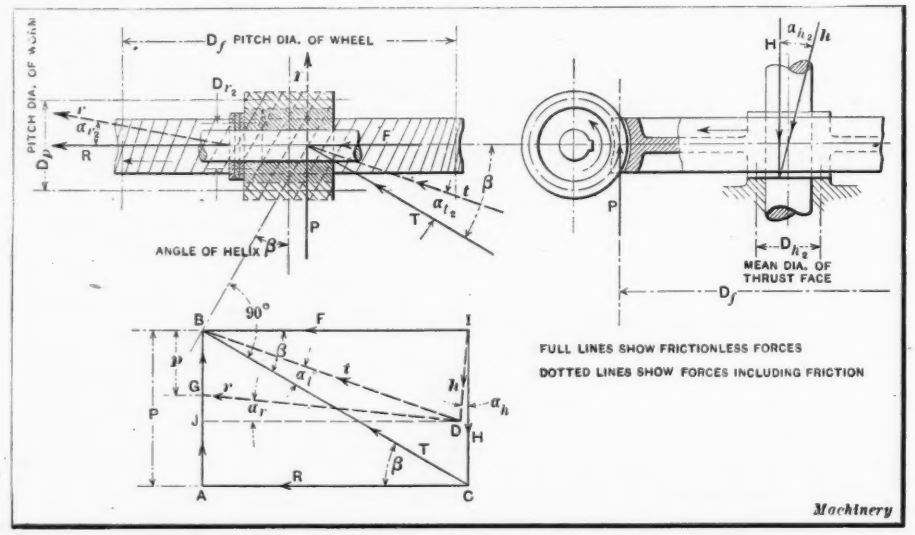

D_f PITCH DIA. OF WHEEL
PITCH DIA. OF WORM
ANGLE OF HELIX
MEAN DIA. OF THRUST FACE
FULL LINES SHOW FRICTIONLESS FORCES
DOTTED LINES SHOW FORCES INCLUDING FRICTION
Machinery

Fig. 3. Forces acting on Worm and Worm-wheel when Wheel is Driver

$$f_{trh} = \frac{P\,[1 - \tan(\beta + \alpha_t) \tan \alpha_h]}{\tan(\beta + \alpha_t) + \tan \alpha_r}$$

The value of F being as previously given, the efficiency is:

$$E_{ptrh} = \frac{f_{trh}}{F} = \frac{\tan \beta\,[1 - \tan(\beta + \alpha_t) \tan \alpha_h]}{\tan(\beta + \alpha_t) + \tan \alpha_r} \qquad (11)$$

If the trigonometric value of $\tan(\beta + \alpha_t)$ is substituted, together with the values $\tan \alpha_r = C_r$ and $\tan \alpha_h = C_h$, this becomes:

$$E_{ptrh} = \tan \beta \frac{1 - C_t \tan \beta - C_h \tan \beta - C_h C_t}{\tan \beta + C_t + C_r - C_r C_t \tan \beta} \qquad (12)$$

Worm and Wheel with Wheel the Driver

The foregoing is for the usual condition; that is, when the worm is the driver. When the worm-wheel is the driver, friction is opposing action in the other direction, the forces being as indicated in Fig. 3. For the theoretical, frictionless drive, $F(= IB)$ is the rotative force acting at the pitch diameter of the worm-wheel, that is, the driving force; $H(= IC)$ is the component of F that acts on the worm-wheel hub; $T(= CB)$ is the component of F that acts normal to the worm teeth; $R(= CA)$ is the component of T that acts against the worm thrust washers; $P(= AB)$ is the component of T that acts as the tangential effort on the worm.

Taking into account the friction: $h(= ID)$ is the force on the worm-wheel hub; $t(= DB)$, the tooth load; $r(= DG)$, the force on the worm thrust washers; $p(= GB)$, the effective tangential force at the pitch diameter of the worm.

The efficiency E_t, when the worm-wheel is the driver, is:

$$E_t = \frac{p}{P} \qquad (13)$$

Limiting Conditions

As angle β approaches a right angle, the theoretical force P increases much more rapidly than the effective force p, and hence the efficiency falls, becoming zero when $\beta = 90$ degrees. For small values of angle β, the effective force p decreases rapidly, becoming zero when angle JDG = angle JDB. From Fig. 3 it can be seen that $JDG = \alpha_r$ and $JDB = DBI = \beta - \alpha_t$. Then $p = 0$ when $\alpha_r = \beta - \alpha_t$; or the worm cannot be driven through the worm-wheel if β is equal to or less than:

$$\beta_{min} = \alpha_r + \alpha_t \qquad (14)$$

In hoisting work or similar service, when the worm is the driver and it is desired that the load will not overhaul, that is, that it cannot drive the worm through the worm-wheel, the lowest possible values of α_r and α_t are used in Formula (14) to determine the maximum safe value of β for a non-overhauling drive.

Formulas for Efficiency with Worm-wheel the Driver

Formulas for the efficiency may now be developed to express the results of the foregoing graphic method. Referring to Fig. 4, $IB = F$ is the driving force applied tangentially at the worm-wheel teeth.

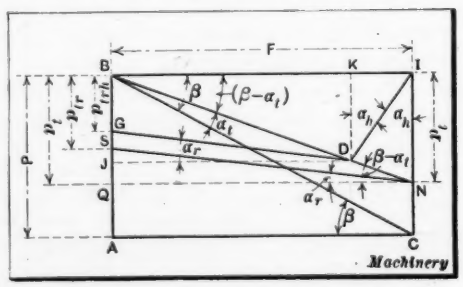


Fig. 4. Diagram used in developing Formulas for Efficiency when Wheel is Driver

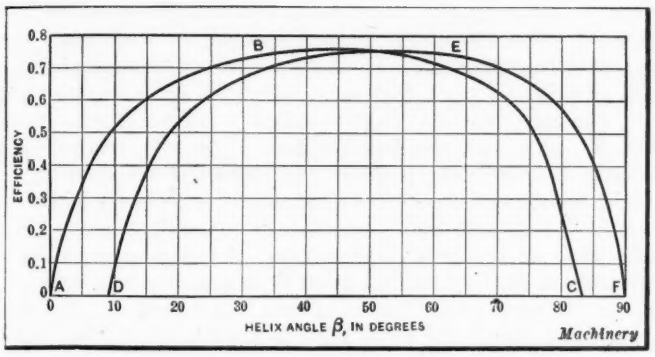


Fig. 5. Efficiency of Worm-gearing for Various Helix Angles

Neglecting friction, CB is the normal tooth load and $AB = P$ is its component acting tangentially to the pitch diameter of the worm. Considering the friction on the teeth only, NB is the tooth load and $QB = p_t$ is the effective tangential component.

Then $P = F \tan \beta$, $p_t = F \tan (\beta - \alpha_t)$, and the efficiency is:

$$E_{tt} = \frac{p_t}{P} = \frac{\tan (\beta - \alpha_t)}{\tan \beta} \qquad (15)$$

From trigonometric formulas, $\tan (\beta - \alpha_t) = \dfrac{\tan \beta - \tan \alpha_t}{1 + \tan \beta \tan \alpha_t}$, also $\tan \alpha_t = C_t$; hence Formula (15) may be expressed thus:

$$E_{tt} = \frac{\tan \beta - C_t}{\tan \beta \,(1 + C_t \tan \beta)} \qquad (16)$$

Considering now the friction of the worm thrust bearing as well as the tooth friction, in Fig. 4, NB is the tooth load and $SB = p_{tr}$ is the effective tangential force developed at the worm. $QS = F \tan \alpha_r$, $p_{tr} = p_t - QS$. Substituting values of p_t and QS, $p_{tr} = F \tan (\beta - \alpha_t) - F \tan \alpha_r = F [\tan (\beta - \alpha_t) - \tan \alpha_r]$, and the efficiency is:

$$E_{ttr} = \frac{p_{tr}}{P} = \frac{\tan (\beta - \alpha_t) - C_r}{\tan \beta} \qquad (17)$$

Substituting in this the trigonometric value of $\tan (\beta - \alpha_t)$ previously given, together with $\tan \alpha_t = C_t$, Formula (17) becomes:

$$E_{ttr} = \frac{\tan \beta - C_t - C_r - C_t C_r \tan \beta}{\tan \beta \,(1 + C_t \tan \beta)} \qquad (18)$$

If the term $C_t C_r \tan \beta$, which is small, is dropped and C_r is taken to equal C_t, as an approximate formula:

$$E_{ttr} = \frac{\tan \beta - 2C_t}{\tan \beta \,(1 + C_t \tan \beta)} \qquad (19)$$

If the friction on the face of the worm-wheel hub is now taken into account, as well as the tooth and thrust bearing friction, in Fig. 4, the line DB represents the tooth load and $GB = p_{trh}$ is the effective tangential force at the pitch diameter of the worm. Then $JD = BK = \dfrac{DK}{\tan (\beta - \alpha_t)}$, $KI = DK \tan \alpha_h$, and $F = BK + KI$, from which $DK = \dfrac{F \tan (\beta - \alpha_t)}{1 + \tan (\beta - \alpha_t) \tan \alpha_h}$. Substituting this in the formula for JD gives:

$$JD = \frac{F}{1 + \tan (\beta - \alpha_t) \tan \alpha_h}$$

Now $JG = JD \tan \alpha_r = \dfrac{F \tan \alpha_r}{1 + \tan (\beta - \alpha_t) \tan \alpha_h}$. But $p_{trh} = GB = JB - JG = DK - JG$. Substituting the values of DK and JG, this becomes:

$$p_{trh} = \frac{F [\tan (\beta - \alpha_t) - \tan \alpha_r]}{1 + \tan (\beta - \alpha_t) \tan \alpha_h}$$

If frictionless, the tangential force at the worm is $P = F \tan \beta$; the efficiency is then $E_{ttrh} = \dfrac{p_{trh}}{P}$. Substituting in this the values of p_{trh} and of P, together with the relations $\tan \alpha_h = C_h$ and $\tan \alpha_r = C_r$, gives:

$$E_{ttrh} = \frac{\tan (\beta - \alpha_t) - C_r}{\tan \beta \,[1 + C_h \tan (\beta - \alpha_t)]} \qquad (20)$$

Expanding this formula by substituting for $\tan (\beta - \alpha_t)$ its trigonometric value $\dfrac{\tan \beta - \tan \alpha_t}{1 + \tan \beta \tan \alpha_t}$, it becomes:

$$E_{ttrh} = \frac{\tan \beta - C_t - C_r - C_r C_t \tan \beta}{\tan \beta \,(1 + C_t \tan \beta + C_h \tan \beta - C_h C_t)} \qquad (21)$$

For the usual proportions, the terms $C_r C_t \tan \beta$ and $C_h C_t$ will be small. Dropping these, the formula becomes:

$$E_{ttrh} = \frac{\tan \beta - C_t - C_r}{\tan \beta \,(1 + C_t \tan \beta + C_h \tan \beta)} \qquad (22)$$

Worm-gear Efficiency Curves

In order to represent more clearly the relation between the helix angle and the efficiency, for both forward and reverse drives, a series of diagrams like Figs. 1 and 3 may be laid out for various values of β and the results plotted as a curve. If in Fig. 1 we choose some convenient scale and make $F = 1$, then f = efficiency. Similarly in Fig. 3, if $P = 1$, then p = efficiency. A number of such diagrams were laid out, with a coefficient of friction $C_{t_2} = C_{r_2} = C_{h_2} = 0.1$, for heavy, slow-speed work, assuming ratios $D_{r_2}/D_{p_2} = 0.6$ and $D_{h_2}/D_{t_2} = 0.2$. The plotted results are shown in Fig. 5, where curve ABC shows the efficiency when the worm is the driver, while curve DEF shows the efficiency when the worm-wheel is the driver. These curves are intended more to illustrate the general law of variation than the actual efficiency for any specific case, the latter being readily determined for the actual quantities involved by the methods previously given.

It will be noted that both curves are comparatively flat for a considerable distance on each side of the point of maximum efficiency. Owing to this peculiarity, there is little choice in efficiency for angles between 30 and 58 degrees when the worm is the driver, or between 40 and 66 degrees when the wheel is the driver. The limiting conditions are brought out clearly. The forward drive point A on the curve represents the helix angle $\beta = 0$; and since there is then no motion transmitted, there is no useful work done; hence the efficiency $E_p = 0$. At point C, the angle is so steep that the worm locks and cannot drive the wheel; hence the efficiency is zero.

For the reverse drive, that is, the wheel driving the worm, at point F the helix angle is 90 degrees, the worm-wheel teeth are at right angles to its axis, the worm has become a spur gear and no motion is transmitted; hence no useful work is done and the efficiency becomes zero. At point D the helix angle is so flat that the wheel cannot drive the worm, and the efficiency is therefore zero. This is the case of a non-overhauling worm drive. It will be noticed that for the angle β corresponding to this point D, the efficiency of the forward drive, as given by curve AB, is approximately 50 per cent. This is, then, the maximum efficiency for a non-overhauling worm of the particular proportions and friction coefficients for which the curves are drawn. In practice, designers make the angle somewhat less than this to provide some margin of safety against overhauling; hence the efficiency is further reduced.

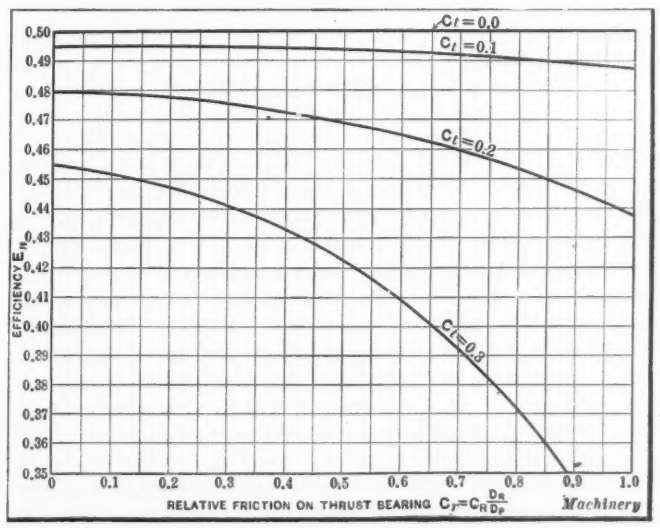


Fig. 6. Maximum Efficiency of Non-overhauling Worm-gears

Efficiency of Non-overhauling Worms

In the foregoing the efficiency of a non-overhauling worm of specific proportions and friction coefficients was shown to be approximately 50 per cent. It will be of interest to deduce a general formula that will give this maximum efficiency directly from the various values involved. The friction on the worm-wheel hub is small when angles β are sufficiently flat to be non-overhauling and may be neglected. The maximum value of the helix angle β for non-overhauling is given by Formula (14) as $\beta = a_r + a_t$, and since the efficiency increases with an increase in the angle on this part of the curve, the efficiency for this condition will be a maximum when this maximum value of the angle is used. Substituting this value of β in Formula (8) gives for the maximum efficiency of a forward drive that is non-overhauling the expression:

$$E_n = \frac{\tan (a_r + a_t)}{\tan (a_r + 2a_t) + C_r} \qquad (23)$$

From Formulas (2) and (4), $\tan a_r = C_r$ and $\tan a_t = C_t$. Then from trigonometric formulas: $\tan (a_r + a_t) = \dfrac{C_r + C_t}{1 - C_r C_t}$

and $\tan (a_r + 2a_t) = \dfrac{C_r + \tan 2a_t}{1 - C_r \tan 2a_t} = \dfrac{C_r - C_r C_t^2 + 2C_t}{1 - C_t^2 - 2C_r C_t}$.

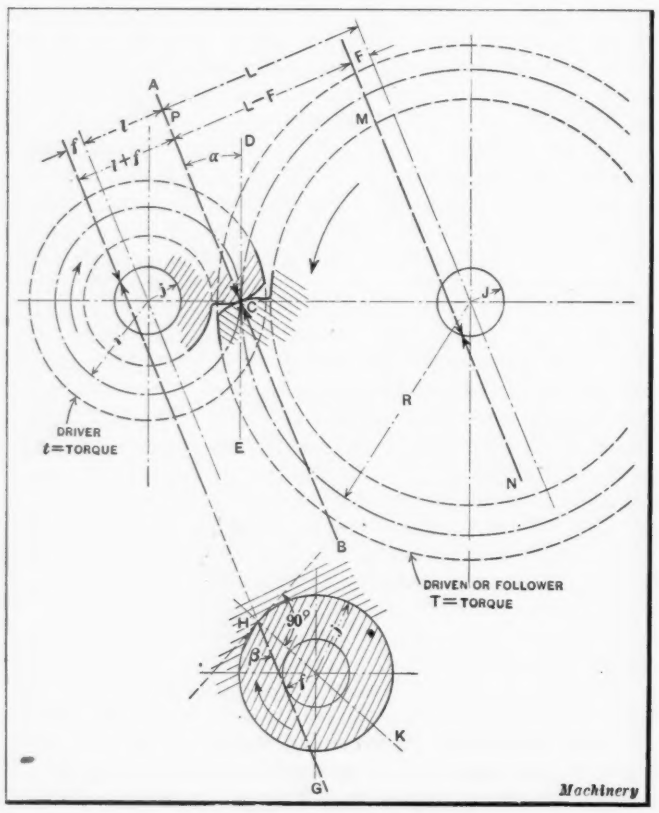


Fig. 7. Forces acting on Spur Gear

Substituting these values in Formula (23) and reducing gives the expression:

$$E_n = \frac{C_r + C_t - 3C_r C_t^2 - 2C_r^2 C_t - C_t^3}{2C_r + 2C_t - 4C_r C_t^2 - 4C_r^2 C_t + 2C_r^2 C_t^3 + 2C_r^3 C_t^2} \qquad (24)$$

When the tooth friction is small, as in well cut worm-gears with an oil bath, the friction of the thrust bearing becomes an important item in preventing the drive from overhauling. If the friction of this bearing is increased, for instance, by increasing its mean diameter, the helix angle β may be increased, causing a decrease in tooth friction that will nearly compensate for the increase in bearing friction. This is advisable, since it decreases the wear on the teeth, the extra wear occurring on the bearing, which is cheaper to replace. This peculiarity is clearly shown in Fig. 6, which shows four curves plotted from values calculated by Formula (24). The upper line for the tooth friction $C_t = 0$ shows the efficiency to have a constant value of 50 per cent, irrespective of the amount of friction on the thrust bearing. With this value of C_t, the helix angle is $\beta = a_r$ or $\tan \beta = C_r$. For $C_t = 0.1$ the curve is also very flat, there being but a slight decrease in efficiency when the thrust bearing friction C_r is as great as ten times the tooth friction C_t. Even for the comparatively high coefficient of tooth friction $C_t = 0.2$, the curve is quite flat.

It thus appears that it is poor economy to use roller or ball bearings on worms that are required to be non-overhauling, since their use would increase the efficiency but little and compel the use of a flat helix angle, which means low efficiency of tooth action and, hence, rapid wear, unless the gears are quite large for the power transmitted. The most striking feature about a non-overhauling drive of this nature is, however, its low efficiency, which cannot be over 50 per cent and may be considerably less if the helix angle is made much flatter than its maximum value. By arranging a simple automatic brake to make the device non-overhauling and using a quick-pitch worm, an efficiency of 75 per cent may readily be obtained and the drive will have a longer life.

Spur Gear Efficiency, Pinion versus Gear as Driver

As a sequel to the foregoing the spur gear problem is treated in a somewhat similar manner. It is quite generally believed that, with a set of spur gears, if the smaller gear of the pair is the driver, the efficiency is higher than when the larger gear is the driver; that is, that the efficiency for a velocity reduction is higher than for a velocity increase. Stated another way, "gearing down" is more efficient than "gearing up." Just why this should be so is perhaps not so generally understood. It is not the object here to discuss the amount of sliding that takes place between the gear teeth, the probable amount by which the friction on the arc of approach exceeds that on the arc of recess, or the many other factors entering into the problem of tooth friction which are fraught with considerable uncertainty; but to consider the journal friction only, with especial reference to the contrast between the efficiencies for forward or reverse drives.

Referring to Fig. 7:

r = pitch radius of driver;
R = pitch radius of follower;
j = journal radius for driver;
J = journal radius for follower.

Consider AB as the line of action, passing through the point of tooth contact C and making an angle a (known as the angle of obliquity) with the tangent line DE. If the teeth were frictionless, a line representing the forces acting upon the teeth would coincide with this line of action. However, in addition to the rolling of the teeth upon each other, more or less sliding takes place, and in order to make line AB represent approximately the correct direction of the forces acting on the bearings, angle a must be taken greater than the angle of obliquity. If K is the coefficient of tooth friction, a is the angle of tooth obliquity plus an angle having K as its tangent.

The tooth load P, acting along line AB, has its equal and opposite reactions at the bearings. In order for sliding to occur, these reactions do not pass through the center of the journals, but, as indicated by GH, make an angle β with the normal line HK such that tangent β = coefficient of journal friction. In the figure, f and F represent the amount the forces pass to one side of the journal center and may be termed the frictional lever arms of the journals. If C = coefficient of journal friction, $\tan \beta = C$, $f = j \sin \beta$, and $F = J \sin \beta$. But for small angles the sine and tangent are about equal, hence:

$$f = jC \qquad (25) \qquad F = JC \qquad (26)$$

The lever arm of the driver, including friction, is then:

$$l + f = r \cos a + jC \qquad (27)$$

The similar lever arm of the follower is:

$$L - F = R \cos a - JC \qquad (28)$$

Let t be the torque expended at driver and T the torque developed at follower; then:

$$T = t \frac{L - F}{l + f} = t \frac{R \cos a - JC}{r \cos a + jC} \qquad (29)$$

If the drive were frictionless, the torque developed would be:

$$T_{theo} = t \frac{R}{r} \qquad (30)$$

The efficiency, being the actual torque divided by the theoretical torque, is then:

$$E = \frac{T}{T_{theo}} = \frac{R\cos\alpha - JC}{r\cos\alpha + jC} \times \frac{r}{R} = \frac{\frac{\cos\alpha}{C} - \frac{J}{R}}{\frac{\cos\alpha}{C} + \frac{j}{r}} \qquad (31)$$

For a given angle of obliquity and coefficient of friction, $\frac{\cos\alpha}{C}$ = constant. If the diameter of the journals were proportional to the diameter of the gears, that is, if $\frac{J}{R}$ = constant and $\frac{j}{r}$ = constant, according to Formula (31), the efficiency would be constant irrespective of the relative sizes of the driver and follower, that is, irrespective of the gear ratio and of whether it was a velocity increase or a velocity decrease. But the diameter of the journals cannot be said to bear any such constant ratio to the diameter of the gears; and while no specific rule can be established, each peculiar case being a law unto itself in this respect, we can generalize to a certain extent.

Any general analysis intended to illustrate how the efficiency varies for various gear ratios, when driving forward or backward, must be based upon some assumed proportions and constants, or else be exceedingly complex. It is here assumed that the two sets of journals are of equal size and that the gear centers are constant, which makes the size of both gears vary for a varying gear ratio; also a high coefficient of friction suitable for slow-speed, heavy-duty work is chosen.

Assuming the gear centers to be 24 inches, that is, $R + r = 24$; the journals to be 3 inches in diameter, $j = J = 1.5$; taking angle $\alpha = 14.5 + 5.5 = 20$ degrees; and the coefficient of friction $C = 0.1$, by substitution in Formula (31):

$$E = \frac{\frac{\cos 20}{0.1} - \frac{1.5}{R}}{\frac{\cos 20}{0.1} + \frac{1.5}{r}} = \frac{9.4 - \frac{1.5}{R}}{9.4 + \frac{1.5}{r}} \qquad (32)$$

This is an empirical formula for the journal efficiency corresponding to the specific assumed conditions. Values of R and r for various gear ratios were inserted in Formula (32) and the efficiencies calculated. The results for ratios from 1 to 20 are plotted in Fig. 8. The upper curve gives the efficiencies when the smaller gear of the pair is the driver, the velocity ratios for this curve being velocity reductions. The lower curve is for the efficiency when the larger gear of the pair is the driver, that is, for a velocity increase. This lower curve thus represents the reverse drive if the upper curve is considered the forward drive.

Limiting Conditions

It is not practicable to secure excessive velocity reductions with one pair of spur gears, as the pinion becomes too small

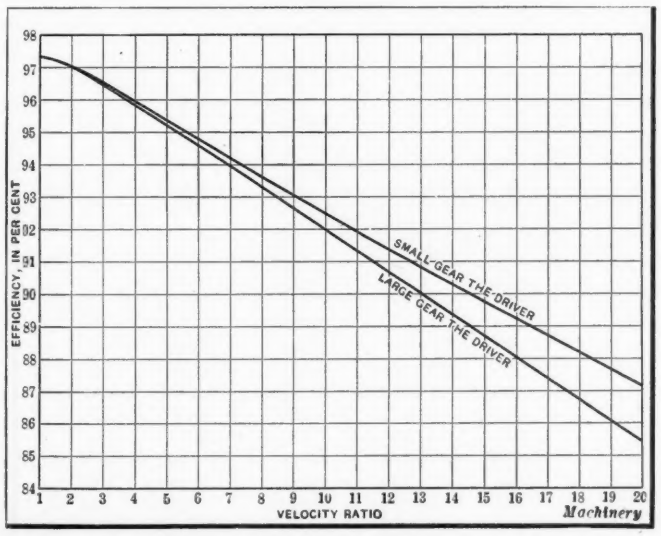


Fig. 8. Reverse Efficiency of Spur Gears, Bearing Friction only considered

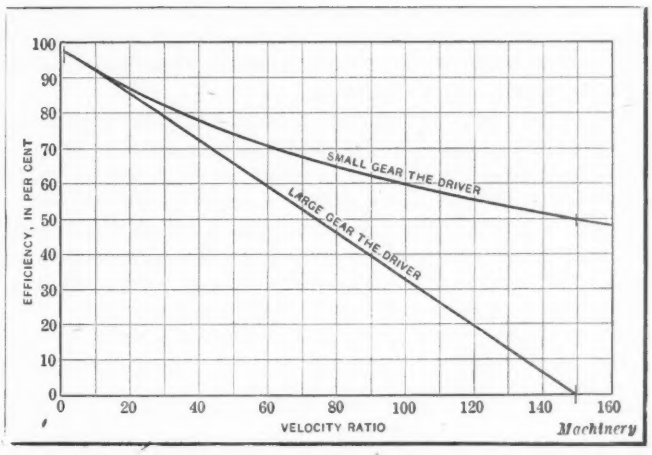


Fig. 9. Reverse Efficiency of Spur Gears Same as Fig. 8 but with Curves extended

for strength or the gear too large for convenience. With a given journal diameter and center distance, the smaller the pinion the less is the efficiency. The theoretical limit is reached when the radius r of the driver is zero. The velocity reduction is then infinite, there is consequently no motion transmitted, no useful work is done, and the efficiency becomes zero. The practical limit of velocity reduction depends entirely on specific conditions, but is seldom more than 10 to 1.

For a velocity increase, the theoretical limit is reached when the lever arm of the driven gear has been reduced until it is equal to the journal frictional lever arm, that is, when $L = F$. This would be when AB, Fig. 7, coincides with MN. The gears would lock because the tooth load would be sustained by the journal without developing any torque, since the applied force would have no effective lever arm. This would be a case of a non-overhauling drive. Expressed as a formula, the minimum radius of the driven gear is:

$$R_{min} = \frac{JC}{\cos\alpha} \qquad (33)$$

In Fig. 9 curves for the specific proportions represented by Formula (32) have been carried out to show this theoretical limiting condition, which is indicated by the lower curve cutting the zero line at a velocity ratio of about 149.4 to 1. It will be noted that for the same ratio of velocity decrease the upper curve shows an efficiency of approximately 50 per cent.

In the case of worm-gears, it was shown that the maximum efficiency of a non-overhauling drive was 50 per cent. In fact, it is a rule applicable to a large class of mechanism that when the efficiency of a device is 50 per cent or less its reverse efficiency is zero, and it is therefore non-overhauling. The most notable exceptions to this rule are those devices in which the friction is an exponential function of the driving force, a familiar example of which is an automatic brake.

Effect of Lubrication on Friction

The foregoing is all predicated upon a constant coefficient of friction for a specific case, so that friction varies directly as the load applied to the rubbing surfaces. In older textbooks on machine design this is recognized as one of the laws of friction. It is now known that this is only true for greasy or poorly lubricated surfaces.

Surfaces that are chemically clean adhere to one another and present a variety of phenomena, depending on the nature of the materials and the smoothness of the surfaces. Surfaces which are slightly unctuous, that is, not absolutely clean, approach the condition of friction being proportional to pressure. When perfect lubrication exists, there is no actual contact of the rubbing surfaces, for the surfaces are separated by a film of lubricant; in this case the resistance to motion depends on the nature of the lubricant. This film of lubricant interposed between the moving surfaces is virtually at rest in relation to the surface where it is in immediate contact with that surface, and the sliding motion occurs between successive layers of the lubricant itself. It is thus "being sheared," and its shearing strength, which is another way of viewing viscosity, is the real measure of friction. This shearing resistance does not increase directly as the load, as does the friction of slightly

greasy surfaces. In fact, it may decrease slightly with an increase of load, so that for perfect lubrication the friction is nearly independent of the load and depends on the velocity and the viscosity of the lubricant.

Where there is imperfect lubrication the surfaces are partly separated by a stable oil film, and at spots the film is ruptured or broken down and contact occurs. The contact is, however, not between chemically clean surfaces, so that adhesion does not take place, although some abrasion may occur. This case is then somewhere between the laws governing perfect lubrication and those usually applied (as in the preceding discussion) to low-speed, heavy-service bearings.

For high-speed perfect lubrication the term coefficient of friction is a misnomer. The real resistance to motion is in the viscosity or shearing strength of the film of lubricant separating the surfaces.

Summary

The graphic methods of Figs. 1 and 3 offer a ready solution of worm-gear efficiency problems. Their principal advantage over formulas is that the individual influence of the various quantities involved is more apparent. The contrast between the efficiency for a forward or reverse drive is clearly indicated by the curves of Fig. 5. Somewhat similar curves for forward drives have been published, but, so far as known, this contrast has not been clearly pointed out.

Formulas for efficiency are given for those who prefer them to the graphic method. For a forward drive, that is, when the worm is the driver, Formula (6) or (7) may be used, each including tooth friction only; Formulas (8), (9) and (10), though, include tooth and thrust bearing friction; and Formulas (11) and (12) include tooth, thrust bearing, and worm-wheel hub friction. For a reverse drive, that is, where the worm-wheel is the driver, Formulas (15) and (16) may be used, each of which includes tooth friction only; Formulas (17), (18) and (19), though, include tooth and thrust bearing friction; and Formulas (20), (21) and (22) include tooth, thrust bearing and worm-wheel hub friction. Formulas (10), (19) and (22) are approximations only, and Formulas (6), (8), (11), (15), (17) and (20) have the simplest forms; the others given for worm-gear efficiencies are expanded to take the same form as those usually quoted.

For non-overhauling worms, the maximum efficiency is given by Formulas (23) and (24) and by the curves of Fig. 6. For this condition, the efficiency cannot exceed 50 per cent, and roller or ball bearings are not generally desirable, since the helix angle must be reduced to secure non-overhauling.

* * *

TRAINING CRIPPLED SOLDIERS

Every industrial country has an army of cripples who suffered their injuries in the pursuit of various trades and activities incident to trade or manufacture. The war will make many more cripples and it will bring before us acutely the necessity of training these men to earn their living at useful labor. A government bureau to promote the training of industrial and war cripples may result, which will direct the teaching of teachers for this work. At present there is little being done systematically in this country to teach cripples to do work that is useful. The blind have been given some training, but the work should be extended to include cripples of all kinds. In this connection it is of interest to consider what is being done for the blind soldiers in France. Besides learning Braille in all branches, they are taught typewriting, stenography, commercial courses, music, handicrafts, modeling, sports, games, etc. In fact, they are instructed in any branch that will enable their training to be of the greatest service to themselves and to the community.

The training of cripples should be conducted with reference to their previous training and aptitude, so that they can continue to carry on work for which they are best adapted. They should be so taught that their efficiency will be as high or nearly as high as that of normal persons. Let us have organized industrial training for cripples started immediately in order that when the acute need for teachers is felt they will be available.

* * *

WEIGHT OF IRON BOLTS AND NUTS

BY GEORGE W. CHILDS[1]

By means of the accompanying table, the weights of United States standard bolts and nuts can be readily found. For example, the weight of a 1⅝-inch bolt 6 inches long, with a square head and nut, is found to be 8.055 pounds. This result is obtained by multiplying by 6 the weight per inch of a 1⅝-inch bolt, or 0.588 pound, and adding to this the weight of the head, 2.356, and the weight of the nut, 2.171; thus $6 \times 0.588 + 2.356 + 2.171 = 8.055$ pounds. In the same way, the weight of a 5½-inch bolt 12 inches long, with a hexagonal head and nut, is found to be $6.732 \times 12 + 71.22 + 60.413 = 212.417$ pounds.

* * *

Researches by the United States Coast and Geodetic Survey prove conclusively that the mountains (at least in the United States) are not held up above the surface of the sea by the rigidity or strength of the earth's materials, but by the fact that underneath them the materials (in the outer portion of the earth) are lighter than normal. The higher the mountain or plateau, the lighter is the material underneath it, which extends down to a depth of about 60 miles. On the other hand, the bottom of the ocean is depressed because the material underneath it, to a depth of about 60 miles below sea level, is heavier than normal. The normal condition may be considered that which obtains in the large river valleys and under the coastal plains.

[1]Address: American Steel Foundries, Chester, Pa.

WEIGHT OF IRON BOLTS AND NUTS

Diameter of Bolt, Inch	Weight, Pounds					Diameter of Bolt, Inches	Weight, Pounds				
	Bolt per Inch	Square Head	Square Nut	Hexagonal Head	Hexagonal Nut		Bolt per Inch	Square Head	Square Nut	Hexagonal Head	Hexagonal Nut
¼	0.014	0.018	0.015	0.015	0.012	2	0.890	4.272	3.945	3.700	3.312
5/16	0.022	0.029	0.025	0.025	0.021	2¼	1.127	6.003	5.513	5.198	4.481
⅜	0.031	0.045	0.040	0.039	0.034	2½	1.391	8.146	7.492	7.054	6.084
7/16	0.043	0.058	0.053	0.058	0.050	2¾	1.683	11.817	9.843	9.307	7.979
½	0.056	0.094	0.085	0.081	0.071	3	2.003	13.851	12.237	11.994	9.894
9/16	0.070	0.127	0.099	0.110	0.096	3¼	2.351	17.500	16.014	15.155	12.965
⅝	0.087	0.168	0.153	0.145	0.127	3½	2.726	21.740	19.900	18.827	16.106
¾	0.125	0.273	0.250	0.238	0.206	3¾	3.129	26.615	24.381	23.047	19.729
⅞	0.170	0.416	0.381	0.360	0.313	4	3.561	32.170	29.385	27.862	23.754
1	0.223	0.598	0.552	0.520	0.453	4¼	4.020	38.448	35.095	33.296	28.358
1⅛	0.282	0.834	0.769	0.797	0.630	4½	4.506	45.493	41.509	39.400	33.488
1¼	0.348	1.120	1.030	0.970	0.842	4¾	5.021	53.351	48.668	46.200	39.300
1⅜	0.421	1.465	1.353	1.269	1.127	5	5.563	62.065	56.547	53.775	45.640
1½	0.501	1.875	1.725	1.624	1.409	5¼	6.133	71.680	65.252	62.075	52.645
1⅝	0.588	2.356	2.171	2.040	1.771	5½	6.732	82.240	74.887	71.220	60.413
1¾	0.682	2.912	2.690	2.521	2.217	5¾	7.358	93.789	85.247	81.219	68.729
1⅞	0.782	3.549	3.267	3.069	2.660	6	8.011	106.372	96.737	92.118	77.792

Machinery

MULTI-MACHINING IN PRODUCTION QUANTITIES

JIGGING THE WORK ON MULTIPLE-SPINDLE DRILLING MACHINES

BY A. E. CARLE [1]

IN multiple drilling, reaming, countersinking, counterboring, or end-milling pieces in production quantities, using standard multiple-spindle drilling machines, the method of jigging the piece is of considerable importance. Consider setting up for the drilling and reaming of six ⅝-inch holes in the flange of the inner hub of a wire wheel for an automobile. The holes are drilled and reamed, with a 0.003-inch tolerance, on a bolt circle of approximately six inches.

The first and most simple method is to place the piece in a suitable jig and use individual slip bushings so that after the holes are drilled, the bushings can be replaced with reamer-size bushings, the jig moved under the reamers, and the holes machined. The loss of time in handling these slip bushings is so great that the production costs increase very rapidly, especially when the operator has to stop to pry up bushings with a screwdriver or some other tool, as is often the case. This style of bushing will frequently catch the drilling or reaming tool and turn with it, thus wearing the bushing plate. To prevent its turning, a number of engineers use the groove-cut bushing, with which most shop men are familiar. This consists of an ordinary slip bushing in which a slot is cut spirally around one-quarter of the outer periphery. This slot accommodates a pin in the bushing plate, so that when the bushing starts to slip, the pin prevents its making a full turn. One source of trouble from individual slip bushings is the accumulation of chips, which must be carefully removed before the bushings are changed; another is the possibility of interchanging the drilling and the reaming bushings (even though they are carefully marked) and thus spoiling the tools or the work.

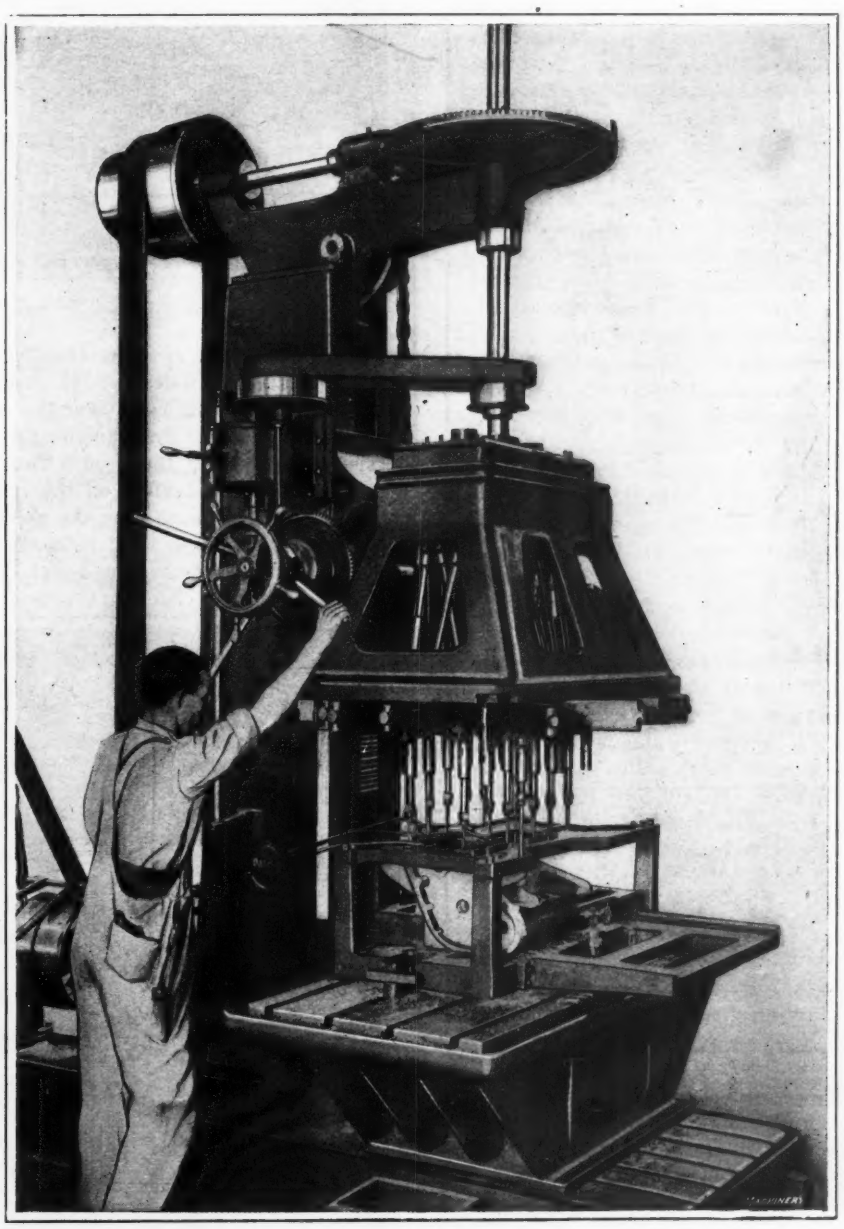


Fig. 1. Plate Bushing Holders used in machining Crank-cases on Multiple-spindle Drilling Machine

An improvement over the individual slip bushings is the plate bushing holder, which is especially useful on such work as crank-cases, cylinders, etc., and in practically all work where six or more holes are to be machined. The work is placed in a box jig or frame in which there are either two dowel-pins or two slots. The removable bushing plates used with this frame have holes or hinged binders to correspond with these pins or slots and so are correctly located. Large pieces may be handled in a similar way to that used in machining the crank-cases shown in Fig. 1. Here the case is mounted on a slide, shoved into the frame, and there securely clamped. Attention is called especially to the handwheel for clamping the slide and the simple construction of the frame. After the holes are drilled, the piece is removed and taken to a machine similarly arranged where the reaming and the counterboring are done. This method necessitates two handlings but is, nevertheless, economical.

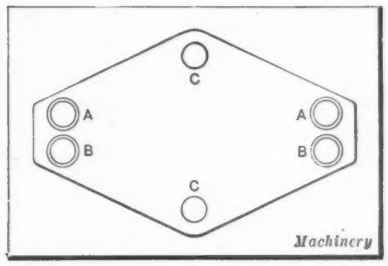


Fig. 3. Small Piece machined by Use of Indexing Jig shown in Fig. 4

A combination roughing drill and finishing reamer, shown in Fig. 2, is used in a number of the automobile factories for drilling and reaming holes in one operation. The lower part is a three-lip drill and the upper, a rose reamer. This tool is guided in the bushing by the reamer flutes. Although this combination tool practically halves the production time, its use is not always economical because of the cost of special construction.

In a large plant in Springfield, Mass., the drilling and reaming are done with multiple-spindle drills without the use of separate bushings for the drills. The material is malleable iron and the piece is placed in a box jig provided with reamer-size bushings only. On the multiple-drill table, there is a V-

[1] Address: Baush Machine Tool Co., Springfield, Mass.

Fig. 2. Combination Drill and Reamer

block in which the jig is placed for the drilling operation. The drilling is against a finished surface, and great care is taken to have the spindles of the machine lined up accurately and the drills carefully ground. These points insure, for the most part, the correct location of the holes and prevent any side running of the reaming tools, which remove only 1/64 inch. The reamed holes must be within limits of ± 0.003 inch, so this method is sufficiently reliable.

The production of multi-machined parts is increased greatly when an indexing table having two or more stations is utilized. As in this case an accurate indexing method must be used, the indexing table is frequently quite costly to make. The practice is to carry a bushing plate or fixed center head on the post

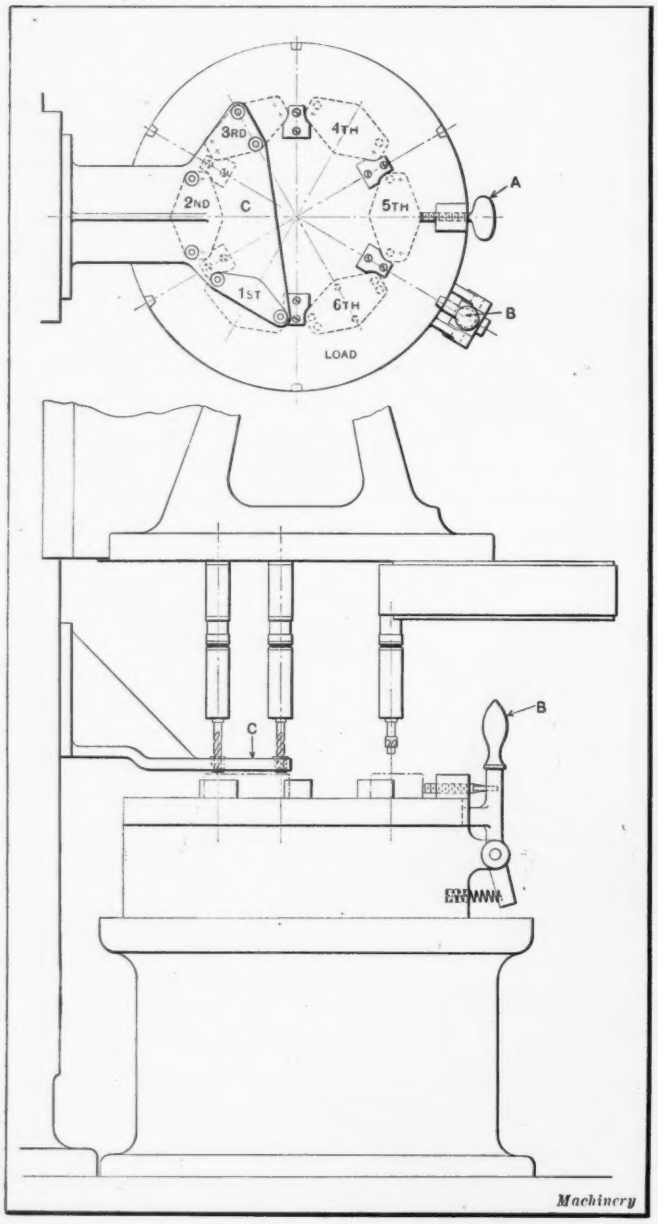


Fig. 4. Indexing Table with Six Stations in Use on Multiple-spindle Drilling Machine

of the drilling machine. In drilling six holes at close center distances and counterboring four holes in the piece shown in Fig. 3, the six-station revolving table illustrated in Fig. 4 is used. Although the table is shown without projecting handles, they are generally furnished for the convenience of the operator. Thumb-screw *A* holds the pieces in place and a handle *B* is provided for locking and releasing the table before and after indexing. Ten spindles are used. The work at the six stations is as follows: First station, drilling holes *A*, Fig. 3; second station, drilling holes *B*; third station, drilling holes *C*; fourth station, counterboring holes *B*; fifth station, counterboring holes *A*; sixth station, loading and unloading. The jig plate *C*, Fig. 4, is fastened to the head of the post for guiding the drilling tools. The counterboring tools are piloted into the drilled holes; if the holes were to be reamed it would be necessary to extend the jig plate over the fourth and fifth stations.

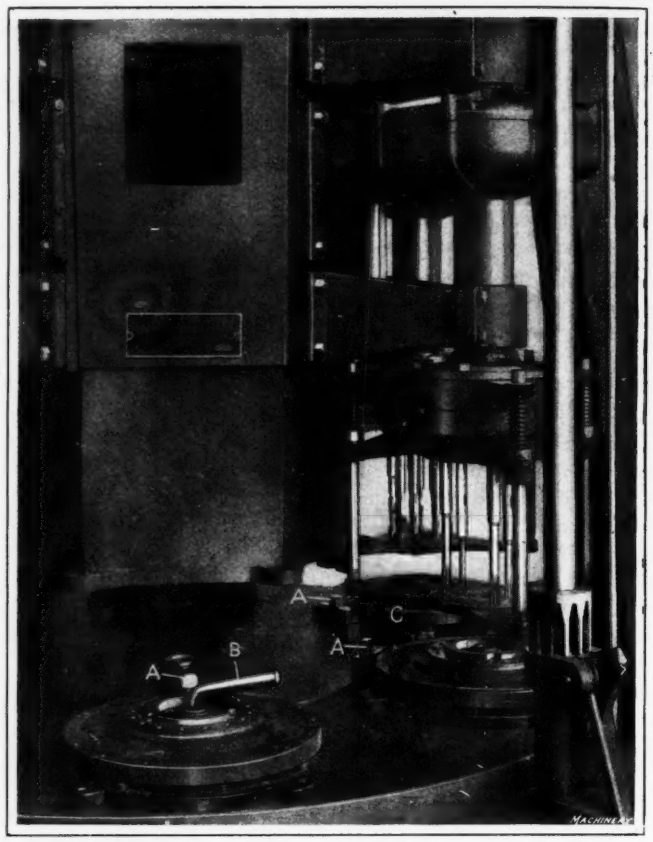


Fig. 5. Machining Ford Flywheels on Multiple-spindle Drilling Machine

Another plan is to arrange the jig plate so that it will be carried integral with the head. This necessitates carrying a number of holding devices on the indexing table, and if extreme accuracy in machining the piece is required these individual holding devices must be arranged to float universally and be accurately centered under the head by a wedge-shaped

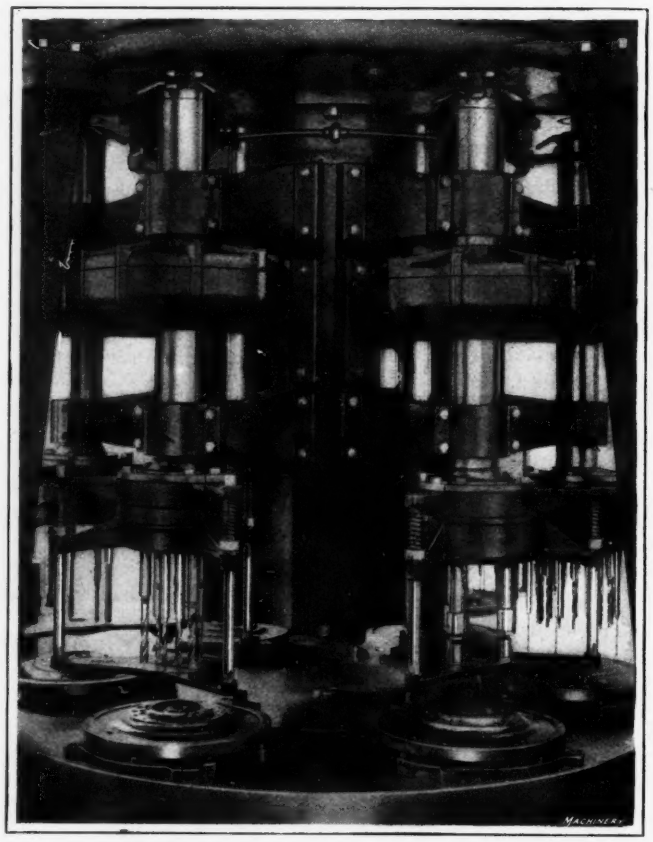


Fig. 6. Arrangement of Large Drills and End-mills for machining Flywheels

piece integral with the head locating in the vee on the holding device. This method produces work as nearly interchangeable as possible and is well illustrated in the Baush station machines for drilling, reaming, counterboring, countersinking, and end-milling the Ford flywheel at the rate of one flywheel every fifty-eight seconds with one operator. The larger number of the holes are held to limits of ± 0.001 inch, and three of the large holes must be as nearly dead right as mechanical means will permit. Fig. 5 shows the tongue *A* on the fixture holding the flywheel. The handle *B* is for clamping and loosening the wheel in the fixture. At the right is shown a reaming head and a jig plate. Fastened to the under part of the plate is a piece *C* grooved to receive the tongue of the holding device. Fig. 6 shows, at the left, a head holding large drills and, at the right, three end-milling tools in the head.

When several small holes necessitating two or more operations are to be machined, the following plan works well from a production standpoint. Pilots of a common diameter are fastened to the drills, reamers and other tools to locate them

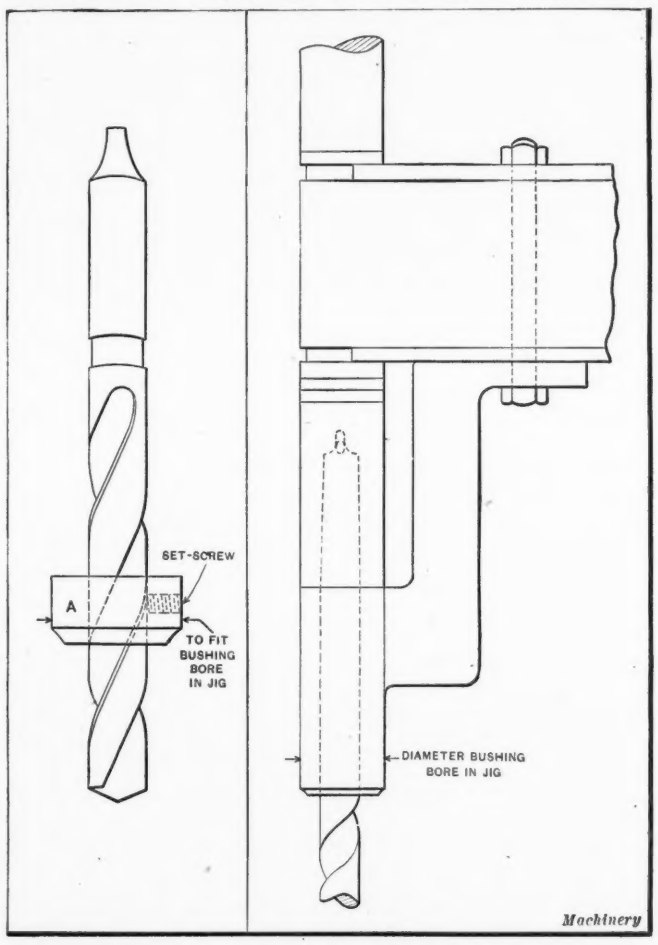


Fig. 7. Drill with Pilot attached

Fig. 8. Stationary Pilot for Multiple Drilling and Reaming Tools

in the bushings in the plate, the bushings having a common bore. Thus, when drilling or reaming, the tools will be guided from the pilot *A*, Fig. 7. This method is not recommended for holes over one inch deep, as there is a tendency for the drills to spring out of alignment, especially if the drilling is done against a rough surface, since the end of the drilling tool will be some distance from the auxiliary pilot guiding it. This arrangement is effective for drilling steel, as the space between the jig plate and the work allows room for the curled chips. The diameter of the pilot, however, must be kept as small as possible, since this piece has a tendency to heat and stick owing to the peripheral speed. This sticking and the wear on the bushing plate may be avoided by using a stationary pilot similar to that shown in Fig. 8. A Z-shaped casting with a bore equal to the tool size and a nose equal to the jig bushing diameter, is secured to the arm of the multiple-spindle drilling machine by a bolt that extends through the slot in the arm, as shown in the illustration. This device is of recent origin and can be used to advantage for multi-machining in quantities.

PENETRATION OF HARDENING EFFECT IN CHROMIUM AND COPPER STEELS[1]

The minimum rate of cooling required to render the influence of quenching efficacious varies according to the quality of the steel. The rate of cooling is lower when hardening special steels than when hardening ordinary carbon steel, so that the penetrative influence of heat-treatment is more efficacious in the case of special steels than in that of carbon steels, and this, as is well known, constitutes one of the chief characteristics of the former.

Steels that contain less than 5 per cent nickel and over 4 per cent copper forge badly. But it has been observed that copper alone, while slightly increasing the depth of penetration of the hardening effect of forgeable steels, does not increase the penetration sufficiently to confer on the steels the property of air-tempering, even when such small parts as bars 10 millimeters square are concerned. In the presence of chromium, however, the copper increases the depth of penetration of the hardening effect.

The addition of nickel to steels containing chromium and copper increases the depth of the penetrative influence of quenching, but to the detriment of the property of softening by annealing. The simultaneous addition of copper, nickel and chromium, permits the easy preparation of steels that possess a tendency to deep penetration of the hardening effect sufficiently marked to render the air-hardening of large enough pieces (for example, gears) efficacious, without such steels losing the property of becoming softened by the annealing processes employed in the case of ordinary carbon steel. Both chromium-copper and chromium-nickel-copper steels possess, after hardening and tempering, practically the same mechanical properties (tensile and impact) as chromium-nickel steels having approximately the same percentage of carbon and the same penetrative capacity for hardening. However, the chromium-copper steels assume, on quenching at somewhat low temperatures, a rather coarser grain on fracture than that exhibited by nickel-chromium steels; there is, therefore, more danger of their becoming burnt. Apart from its influence on the depth of penetrative influence of quenching, the author has failed to detect any useful effect of copper on the properties of steel.

The most common special steels generally contain more nickel than chromium, because the somewhat violent action of chromium is likely to cause cracks while quenching. The rate of cooling required to produce hardening varies within wide limits. It is difficult to insure a uniform degree of hardening when metals requiring a rapid rate of cooling are treated; and, on the other hand, the hardening will be energetic and uniform, though the conditions of cooling vary, in the case of metals that undergo energetic hardening on air-cooling, when they are cooled in a liquid in which the cooling effect is more rapid.

Steels containing at least 1.4 per cent chromium and a little copper or nickel can be quenched in a liquid between the temperature of 120 and 350 degrees (real Colza oil does well) without the energy of the cooling varying much, and under these circumstances there is not much fear of cracks developing.

Generally speaking, pieces of medium thickness (30 millimeters or less), if made from air-hardening steels, soften in ordinary annealing, and after annealing, are easy to machine. Naturally, if it is desired that the hardening effect should penetrate to the core in very thick pieces, or if air-hardening is to be adopted, metals should be employed that have a greater susceptibility to the penetrative effect of hardening.

* * *

The Chicago, Milwaukee & St. Paul Railway is planning to extend the electrification of its road to the Pacific coast. The work is now completed for 416 miles in Montana, where it is estimated that four hours are saved by each train of sixty-two cars on each 100 miles. The electric engines haul heavy freight trains at fifteen miles an hour up grades on which three or four steam engines could pull small trains at only half this speed.

[1]Abstract of a paper by L. Grenet, read before the Iron and Steel Institute of Great Britain, May, 1917.

COMPOUND SUB-PRESS WATCH DIES[1]

MAKING MASTER AND WORKING PUNCHES AND DIES—EXAMPLES OF DIES FOR WATCH PARTS

BY W. H. DUNBRACK[2]

ALTHOUGH many watch parts are punched in drop- and double-action presses, sub-presses are used when very accurate work is required. These sub-presses are of the regular type, except that the bases are made longer than usual and need no clamps to hold them to the bolster of the punch press. A base and means of fastening it to the lathe are shown in Fig. 1. These sub-presses vary in size, by two centimeters per press, from a small open-front press with a plunger two centimeters in diameter, up to a press with a sixteen-centimeter plunger.

When starting to make a die, it is first necessary to see that the sub-press is in good condition. The presses are made by machinists and are "run in" by a machine built especially for that purpose. But this test is not considered good enough for fine watch work, so the plunger is taken out and the babbitt scraped and pressed in again until a good bearing is procured. Usually the babbitt is tightened until the plunger can be driven down by five or six blows of a lead hammer. The upper part of the press is then put on lathe centers, bored out, and faced

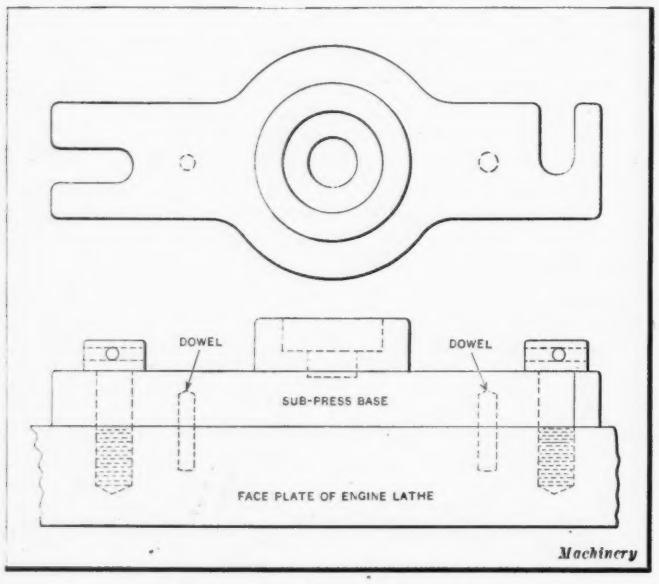


Fig. 1. Extra Long Sub-press Base

true with the plunger; this must be done carefully, or there will be difficulty in aligning the punch and the die later on.

Making Master Punches and Plates

A model of the part to be punched is given to the workman, who makes a master punch to conform with it. The method is as follows: A center hole is drilled and reamed in the model, and when possible, two other holes are drilled and reamed for relocating. The model is then soldered to the master-punch blank, the center hole being located in the center of the blank punch, and then the locating holes of the model are transferred to the punch. This punch is milled almost to the model, about 0.002 inch being left for lapping; if there are square or odd-shaped corners, the punch must be milled until the model is touched by the milling cutter. The model is then removed and the punch is hardened and drawn to a light straw. Then the punch is aligned by lapping the bottom until the center hole runs true with the diameter of the base. After the model is relocated on it by means of pins or dowels, as shown in Fig. 2, the punch is lapped cylindrically by a diamond lap held in the bench lathe, as shown in Fig. 3. The punch is held against a drill pad, or flat center, in the tailstock of the lathe and the lap is revolved at the highest speed possible. The punch is then moved around the lap, using a light pressure, until the model is touched evenly. Master punches are usually made 6 or 7 millimeters long.

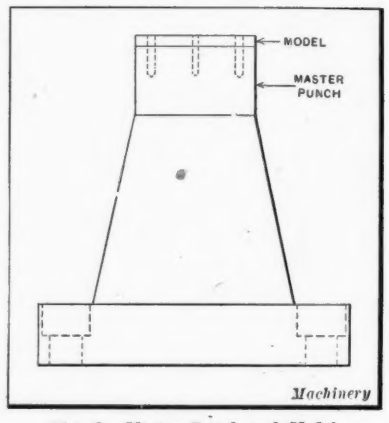


Fig. 2. Master Punch and Model

To make the lap, a piece of drill rod slightly smaller than the smallest curve of the punch is ground true and straight, for a distance of about ⅜ inch. The rod is ground instead of being turned, because diamond powder "charges in" better in a ground surface; grinding also makes a smoother cutting lap. Diamond powder is then rolled in.

For constructing a compound die with piercing punches, a master plate, Fig. 4, is usually made, and this is kept for future reference. A blank plate is clamped to the faceplate of a lathe and a recess about one millimeter deep is turned to fit the base of the master punch; a center hole of some standard size is also bored through the plate, and this size must be maintained on all the holes in the plate. The master punch is then set in the recess, screws and dowels holding it in position, and the plate is moved on the faceplate until the holes in the model on the master punch run true. A very good indicator must be used, as this is one of the most important operations. When a hole is trued, the master punch is taken out and a hole is bored through the plate, corresponding to the hole in the model. When all the holes in the model have been transferred to the master plate, the plate is removed and located "on center" by a pin that fits the center hole of the plate. A larger recess is then turned for the die-holder. All punches and die-holders are standard sizes for a given size of press.

Making Die-holder and Die

The die-holder is left soft. After it is made to fit the recess in the master plate, all the holes in the master plate are transferred to it. Both straight and back taper holes are used, and both are backed up by a hardened plate in the plunger. If straight punches are used, they must have button heads to prevent their being drawn out of the holder. The die blank is then made to fit the holder, which has a taper shoulder of 20 degrees, as illustrated in Fig. 5. The sub-press

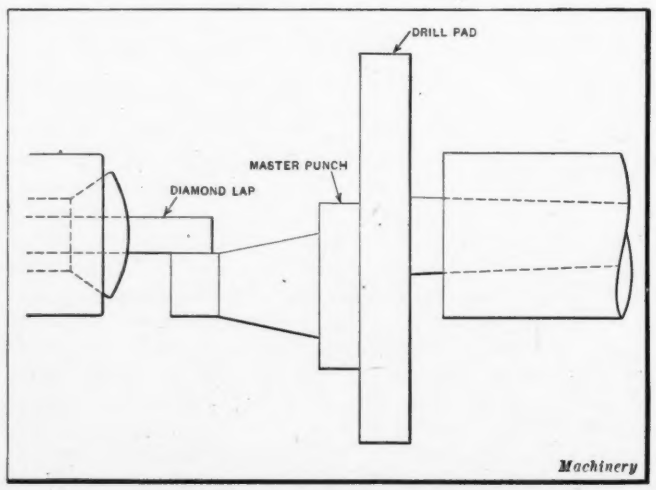


Fig. 3. Lapping Master Punch

[1] For other articles on sub-press dies, see "Sub-press Piercing Die," September, 1914; "Sub-press Dies for Armature Manufacture," July, 1914; "Sub-press Die for Piercing and Shaving," November, 1913; "Sub-press Die for Making a Cleat," August, 1912; "Standard Parts for Pillar Dies," September, 1911; "Operation and Construction of the Sub-press Die," July, 1910, and articles there referred to.

[2] Address: 128 Claremont Ave., Jersey City, N. J.

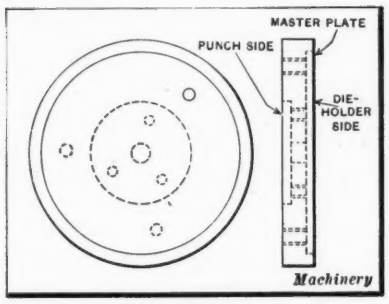


Fig. 4. Master Plate for Die Work

plunger is now recessed to fit the die-holder, and the holder and die are screwed to the plunger.

Sub-press Base

The sub-press bases, Fig. 1, are extra long, as previously mentioned. Two dowel holes of different sizes are drilled part way through the bottom, using a jig, and the dowels are then located in the lathe faceplate to hold the blank base nearly central. Two bolts hold the base to the faceplate, as shown. The base is now recessed for the master punch and the stripper plate; it is also turned to fit the upper part of the sub-press. The advantage of using dowels for locating the base to the faceplate is that if the base has to be relocated on the faceplate, it is not necessary to use an indicator, the two dowels making location certain. The master punch is now located in the base in such a position that the maximum number of pieces can be punched from a given length of stock.

The blank die is next covered with solder and faced off true, to get what is called a "lead impression"; this is generally done in the screw press, but if the master punch is delicate a lead hammer is used. After the die has been drilled out and rough-filed to this impression, the lead is turned off and a steel impression is taken, which need not be more than a few thousandths of an inch deep. The die is then filed to within about 0.002 inch of the correct size, the excess stock being shaved off. The amount to leave for shaving is a matter of judgment rather than measurement; if too much stock is left, the die will tear and rough up and a poor job will result. The shaving is done by pounding the plunger with a lead hammer, as the screw press tears the work; only about 0.015 inch can be shaved at one time. The plunger is then drawn out and the burr, or shaving, is carefully removed. This operation is repeated until the punch has been forced through the die.

Fig. 5. Die-holder and Die

If a very smooth die is required, as in trimming, or compound blanking and swaging work, the die is not shaved by the master punch; but when ready to be shaved, it is hardened. A brass blank is then soldered over the hole and worked out to the design of the die. This blank is shaved by the master punch to the correct shape, and the die is lapped to this shape in a filing machine. For this work a diamond lap, which is a soft file blank charged with diamond powder, is used; No. 1 powder is used for roughing and No. 2 for finishing.

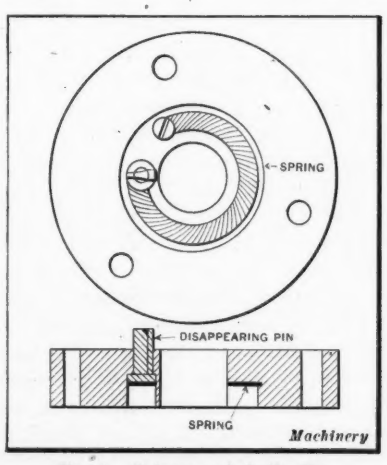


Fig. 6. Stripper and Guide Pin

After the die has been lapped to the brass impression, it will be found that the master punch will not enter the die, as the brass blank shrinks after shaving. The brass impression is then removed and the die is lapped again until the master punch enters the die about 1/32 inch, which means that the die is slightly bell-mouthed. This amount is later ground off, leaving a perfectly straight die, a little smaller than the master punch; it is necessary for the die to be smaller than the punch, as the die blanks expand after coming out of the die.

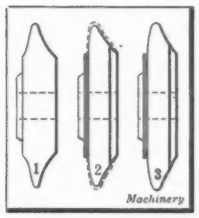


Fig. 7. Rolls for spinning Watch Case

Working Punches

It has been found that, on an average, one die will last as long as eight or ten working punches; hence it is necessary to make a set of punches. The punch blanks are covered with solder, faced off true, and a lead impression is taken from the die. This impression is rough-milled in a bench lathe, using a table rest. Saws and form cutters are used on the saw arbor in the head of the lathe. In this operation, the top of the punch must be set level with the center line of the lathe, or the work will "hog in." The punch is held against the saw, free hand. This is a quick way of milling punches. It gives a radius cut, but all that is wanted is to make a steel impression. The solder is turned or ground off, and a steel impression about 1/16 inch deep is taken. As this is a heavy cut it makes the punch too small. If the punch were milled to this size, there would be nothing to shave, so the edge of the punch is peened slightly or upset and the punch is shaved down again almost to the previous depth.

The punch is now ready for milling, which, again, is a matter of judgment, for if just enough is left for shaving, a smooth punch will result. The punches are set up in the master plate and the holes are transferred in the same way as in making the die-holder, except that the opposite side of the master plate is used. After this, the punches are hardened and drawn to a purple; the dies should be drawn to a light straw. The punches are aligned by lapping the bottom on a cast-iron lap, using fine emery, until they cut tissue paper evenly. This is done by sharpening both punch and die and bringing them together in a sub-press with tissue paper between; then, with a light blow of the lead hammer, the tissue is marked. The side of the punch that cuts the paper first is the side that must be drawn toward the center. If the paper is cut evenly, the punch is in line.

Shedder, Stripper Plate, and Guide Pin

A brass punching is then made. This punching is soldered to the shedder blank, and the shedder blank is milled until the cutter touches the punching. The holes in the master plate must be transferred through the shedder. This is done by putting the master plate on a lathe, the die-holder being placed in the recess of the master plate and the die (with the shedder inserted) on the holder; then the holes are bored as in the holder. The shedder is then hardened, replaced and ground out, using diamond laps if the holes are small.

A stripper plate, Fig. 6, is next made to strip the stock from the lower punch, but it must not fit the punch closely;

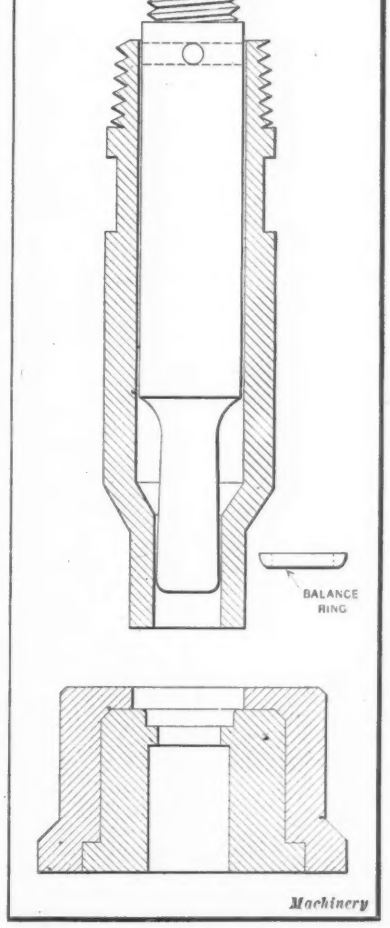


Fig. 8. Double-action Balance-ring Die

there should be a space of 0.004 or 0.005 inch between the punch and the stripper.

A disappearing guide pin seems the best for most work. Sometimes a track slightly wider than the punch is milled through the stripper plate, but this necessitates the use of stock that is perfectly straight and of a certain width, whereas watch stock is rolled for thickness in the works, and is likely to come from the rolls slightly curved. The disappearing pin permits the use of stock of any width; the strip does not have to be held at exactly right angles, but it must be held close to the guide pin.

In the foregoing a general outline of the method of making dies for fine watch work is given. A more detailed description is necessary to give a clear idea of the several varieties of watch dies.

Blanking and Burnishing Dies

Dies for steel parts blank, pierce and burnish the edges in one operation. The die is made as already described, except that the cutting edge is stoned round and polished to a high finish. The radius of the round edge must be determined by experiment; it is best to start with a small corner and work up until the edge of the blank shows perfect burnishing. The inside of the die must be very smooth and the radius of the cornering must blend in without sharp corners. The punches must fit perfectly in the die, or a ragged edge will result on the punching. This method of burnishing, or drawing, the edges of steel work is used in optical work on gold-filled flat stock, in which the pure gold must be drawn from one side, over the edge of the composition, to meet the gold on the opposite side, and withstand the acid test.

Brass and nickel parts are usually blanked and trimmed, the trimming being done in a die about 0.005 inch smaller than the blank. The die is placed in the plunger of the sub-press, the punch being in the base with the stripper and nest to locate the blank. A gash is milled through the back of the sub-press into the plunger, so that punchings may pass through the die and out back of the press. In very high-grade work, a burnishing die must be used after trimming. This die is made slightly tapered and lapped very smooth. The top is large

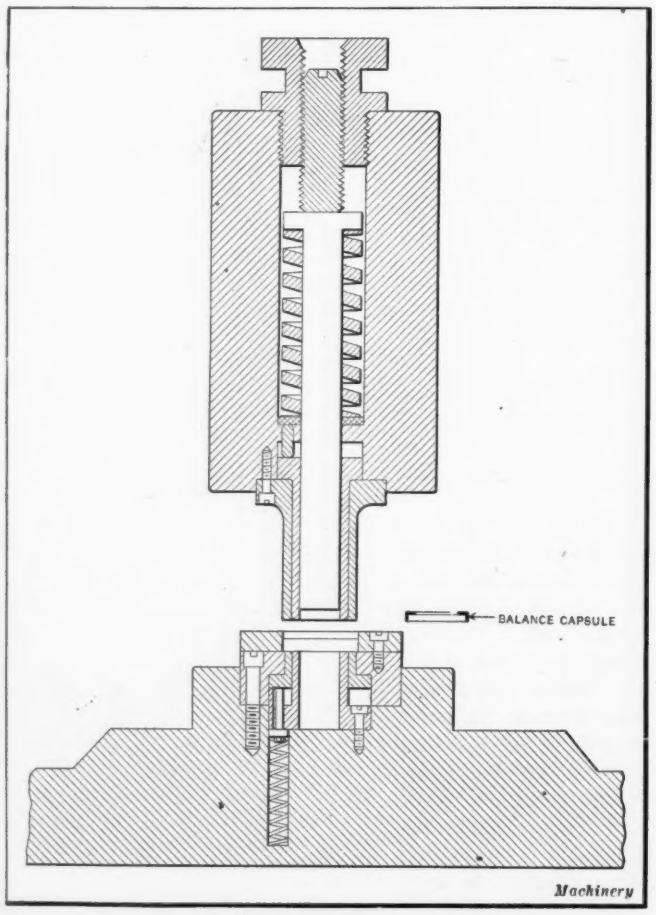


Fig. 9. Balance Capsule Die

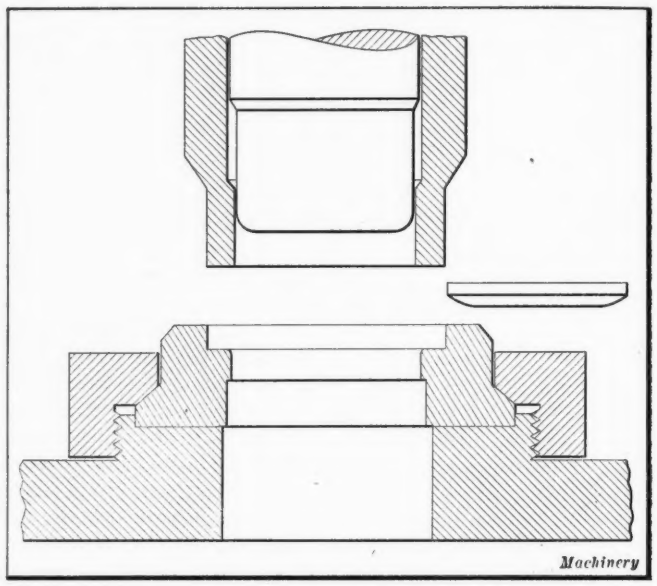


Fig. 10. Blanking and Drawing Die for Watch Case

enough to start a blank without cutting, and the small end is finished to size.

Dies for Balance Ring and Balance Capsule

Brass balance rings are punched from flat stock; they are drawn to cup shape and the bottoms are punched out in one operation. This work, however, is not done in a sub-press, a double-action punching and drawing die being used, as shown in Fig. 8.

Balance capsules are punched from what is called "low brass"; that is, brass that melts at a higher heat than the balance ring, which is a "high brass." These capsules are used to hold the steel center and brass rim of the balance together while brazing, as the brass rim fuses to the steel before the capsule melts. The sub-presses of the capsule dies are not babbitted. The cast-iron shell is bored out perfectly straight and lapped smooth, using a lead lap and emery. The plunger is made from machine steel, casehardened and ground to fit the press; there are no guide slots nor ribs, as in babbitted presses, as the punches are round. Presses made in this way withstand the swaging operation better than the babbitted press. This press is called the double compound die, because it blanks, draws, swages and pierces in one operation. The base contains the blanking die, lower punch and lower shedder; the plunger holds the blanking punch (which is also the drawing die), swaging shedder and center punch. These dies have an automatic roll feed, but to make sure that every piece is ejected, a blast of compressed air is placed so as to strike the capsule as it is ejected from the lower punch, blowing it into a wire basket. This die is shown in Fig. 9.

Watch-hand Dies

The dies for second hands are of the compound type; that is, they blank and pierce the center hole in one operation, using an automatic finger feed. The die is made in two pieces, which are ground together as one, one-half the hand being produced in each piece. In making a die of this kind, the first operation after fitting the sub-press is to make a holder for the split die. This is made with a one-degree taper, one centimeter deep. Two die-blocks are made to fit this holder, and then one-half is cut away, making one block split exactly in the center. The holder is now indicated in the lathe with the split blocks in place, and a center hole is drilled and reamed to the size wanted in the hub of the second hand, leaving enough to lap after hardening. If the hand is of the design known as a "ball second," this hole in the die is also drilled and reamed. The dies are then hardened and drawn. The two parts are blocked or lapped flat on the parts that join. The center hole is lapped to size, using a drill rod or brass lap and flour of emery as an abrasive. The two die-blocks are next held together by wire and soldered. A pin, or arbor, is ground true in the lathe and the die is wrung on and ground

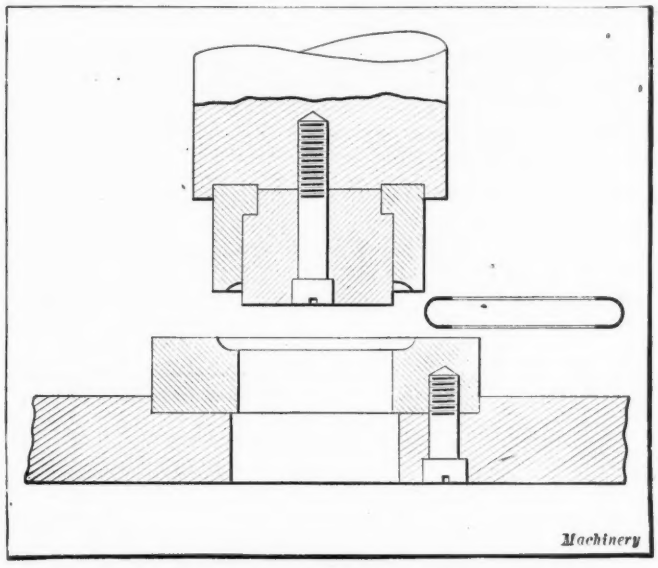


Fig. 11. Punching and Curling Die for Watch-case Rim

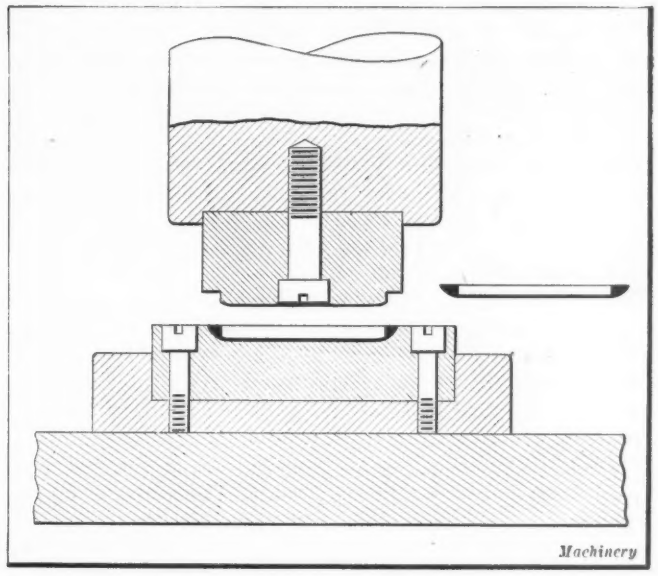


Fig. 12. Swaging Die for Watch Case

on the outside to fit the holder. A novel surface grinder is used to grind the arms, or center-web, and the tail of the hand. A bench lathe is used, with an angle iron having micrometer adjustment in the head of the lathe. The screw is removed from the slide-rest and a cam movement substituted. The diamond form laps are about one inch in diameter. If the second hand is to be a "spade second," a form lap must be used to grind the form of the spade.

The punches are made in large quantities, as their life is short, owing to their delicate size and shape. They are made as already described, except that all the milling is done in the bench lathe. The radius cut of the saw, or cutter, leaves enough of the punch straight to make further milling unnecessary. A depth of 0.025 inch is sufficient, this being reduced after hardening to 0.015 inch. High-carbon steel makes better punches than any other steel, as it can be drawn to a purple, which is the proper color, and still be tough.

Three operations are necessary for making the hour and the minute hands—blanking, swaging and piercing. The blanking dies are made in two pieces, held together with screws and dowels, and used in sub-presses. Swaging is done in a drop-press, as a uniform blow is necessary; the piercing is done in small, open-front sub-presses. The fancy hands are first blanked and the intricate shapes are punched out in separate operations, after which the hands are swaged in drop-presses.

Dies for Metal Dials

Metal dials are made in many shapes other than round. They are blanked and pierced and the figures and dial foot recesses are swaged in one operation. The die is like most compound dies, except that the force, or swage (which is the dial in relief), is on the upper shedder. Therefore, after a blank has been punched, the plunger must be carried down until the shedder "hits bottom." Careful adjustment must be made to swage the figures to the correct depth. The recesses for the dial-foot pins are on the opposite side of the dial from the figures, and are swaged by pins projecting above the surface of the lower punch, backed up by a hardened steel plate under the punch. These swaging pins are very near the rim of the punch, making it difficult to harden the punch without cracking. This difficulty is overcome by drilling the hole part way through from the bottom, leaving about ¼ inch solid, and piping it out after hardening.

The method may be of interest. The punch is aligned by lapping the bottom until the center hole runs true. Then the punch is placed in the master plate and located on the lathe faceplate, as previously described. A pipe is then made, the outside diameter of which is from 0.01 to 0.015 inch smaller than the hole wanted. The hole in the pipe must be large enough to leave only a thin wall of about 0.015 inch. This pipe is mounted in a traverse spindle grinder (care being taken to get the spindle on the dead center of the lathe) and used as a diamond lap, cutting on the end. The speed of the spindle should be about 20,000 revolutions per minute. Loose No. 1 diamond powder is used freely, being placed in the cut; the lap charges itself. After cutting out the center, the hole is brought to size with an ordinary diamond lap.

The swaging plates, which stamp the figures on the dials,

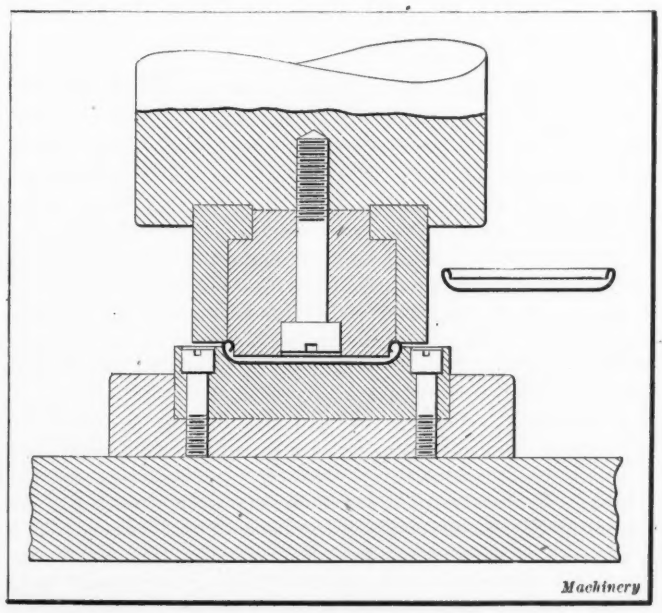


Fig. 13. Curling Die for Watch Case

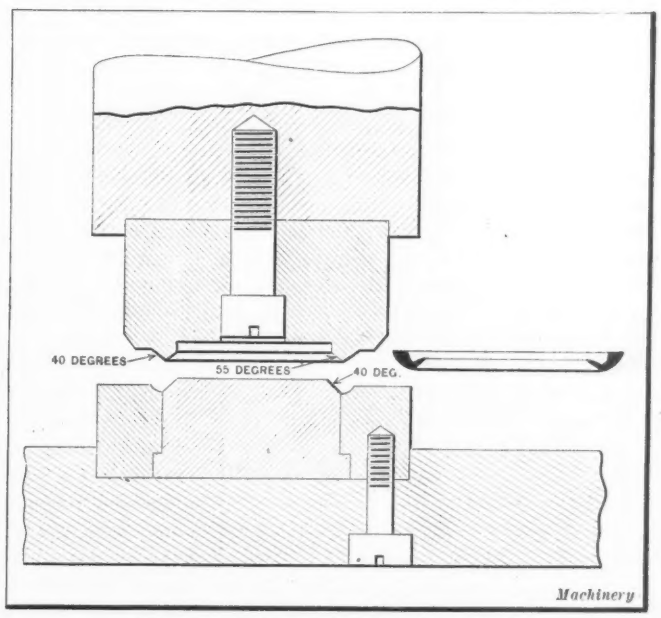


Fig. 14. Swaging Die for Reflector of Bezel

are about 0.055 inch thick, when finished, and are held to the upper shedder by a button stud made from "Hecla" vanadium steel. These plates are first decarbonized and the figures raised by swaging in the screw press. A steel block ½ inch thick is engraved to correspond with the dial, and hardened. The swage blank is placed in the center of the dial block and pressed until the figures are raised perfectly. A punch with flat teeth is used to swage the plate, as small sections are thus driven down at one time, the punch being turned around slightly after each blow of the press.

Swaging Dies

Swaging dies are made by a force or master punch, and are used where rounded shapes and steps are necessary, as in regulators, pallets, etc. Swaging-die blanks are surfaced off and lapped on a ground-glass lap, using powdered oilstone and oil. This gives a dead smooth gray finish, without scratches, which is absolutely necessary, as all imperfections are carried down by the force and cannot be polished out. The force is pressed into the die blank to slightly more than the required depth, and ground off after hardening. The impression is polished with a peg-wood stick and No. 4 diamond powder. Blanks of the part wanted are placed over the impression and struck by a drop-press, leaving a flash, which is trimmed off in the trimming die that also burnishes the edges. The round corners of the trimmer also help to locate the work to be trimmed.

Mainspring Dies

Mainsprings are trimmed on the end, and a hole is pierced in one operation; the presses used for this work are small, open-front sub-presses. Master punches and a series of master broaches for the holes are used when making the dies.

Wheel Dies

Dies for punching the escape wheel and other wheels are compound, but they do not punch the teeth or the center hole. The teeth are cut on a slotted arbor that holds the wheels by the inside of the rim. The center hole is drilled and bored by holding the wheel by the pitch diameter of the teeth in special machines. The most important parts of wheel die work, and the most difficult to make, are the segment punches; they are ground by holding them in a block that has been planed to give correct angles, a surface grinder being used.

Dies for Watch Cases

As an article on watch dies would be incomplete without a description of the dies for the cases, a set of such dies for a plain, nickel, screw-back and bezel case is described. The first operation on the rim is to punch and draw a cup-shaped blank in a double-action press, using a die like that shown in Fig. 10. This die is of the same design as the balance-ring die, except that the blanks do not cling to the center punch, but pass on through the die. As the blank passes the sharp shoulder of the lower die, it expands slightly, which prevents it from returning with the punch. It will be noted that the die is held in the recess of a cast-iron plate by a large hexagonal nut; this method is used on all dies of this kind.

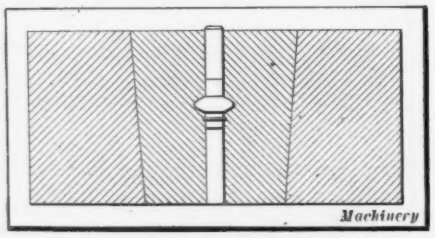


Fig. 16. Die for swaging Pendant

After the work passes through a punching and curling die, Fig. 11, it is ready for spinning; the punching and curling are done in one operation. Spinning a watch-case rim is usually done with three form rolls, shown in Fig. 7; the dies and holder are shown in Fig. 15. These die rings are made interchangeable to facilitate quick operation. The rings are ground absolutely smooth and all grinding marks are lapped out, as the slightest amount of wear on the angles will make an imperfect fit, producing fins and burrs on the work. The die and holder (with the ring in place) are held by hydraulic pressure in a spinning machine, and the first roll shown in Fig. 7 is placed on a bar and inserted in the die through the large hole. By the use of an eccentric lever, the roll is forced into the ring. The first roll is an opener, the second roll forms the center of the rim, but not the bottom, and the third roll is the finishing roll, which leaves the rim ready to thread; this is done in a bench lathe with a threading attachment.

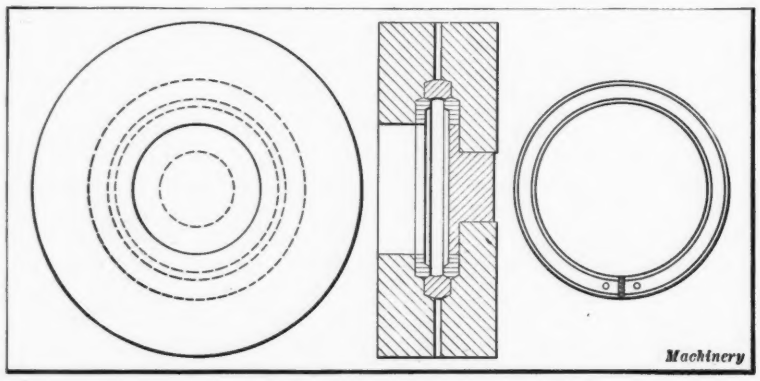


Fig. 15. Spinning Die and Holder for Watch Case

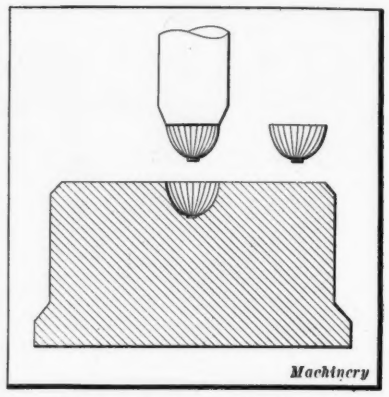


Fig. 17. Die for swaging Crown

Watch-case backs are blanked and drawn in a die like that shown in Fig. 10. These blanks are then passed through a curling die, Fig. 13, which curls the blank to the form shown; this die is used in a sub-press. After the curling operation, the back is swaged, as shown in Fig. 12, which leaves the work ready to thread. This operation, as in the case of the rim, is done in a bench lathe with a threading attachment. The bezel is the same as the back, except that the bottom is punched out after swaging. A die that swages the reflector of the bezel is shown in Fig. 14. The pendant die, shown in Fig. 16, is a two-piece die; one-half of the pendant is worked out of each section, both pieces being held in the hardened ring. A piece of hardened wire is placed in the lower part of the die with a piece of nickel wire in the center, ready to swage. Another hard pin is placed on top of the nickel wire, and when forced down, swages the wire into the desired form. A die for swaging crowns is shown in Fig. 17. The blank crown is curled and swaged on the stem. There are, of course, other operations on watch-case work, but this description is confined to the die work.

* * *

THE SOCIETY OF INDUSTRIAL ENGINEERS

The Society of Industrial Engineers was organized in Washington, D. C., June 15, and Charles Buxton Going, for twenty years editor of the *Engineering Magazine*, New York City, was chosen provisional president and pro tem chairman of the board of directors. This board comprises fifteen prominent men, chosen from various sections of the United States, among whom are Charles Buxton Going, C. E. Knoeppel, Frank B. Gilbreth, E. C. Shaw, Harrington Emerson, Charles Piez, Irving A. Berndt, G. DeA. Babcock, Willard E. Hotchkiss, Harry Franklin Porter, H. Thorpe Kessler, Dexter Kimball, Morris L. Cooke, C. Day and Herman Schneider.

The society is to be a national organization and the membership will comprise men and women who are industrial engineers, professional technical engineers, accountants, managing executives of commercial and industrial activity, writers, educators and students. Upon completion of the organization its services will be tendered to the government through Howard E. Coffin, chairman of the Advisory Committee, Council of National Defense, and others who can utilize its services.

LETTERS ON PRACTICAL SUBJECTS

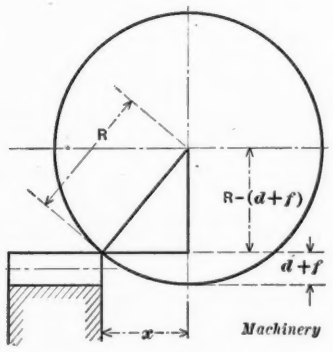
We pay only for articles published exclusively in MACHINERY

TRAVEL OF CUTTER WHEN MILLING GEAR TEETH

It is well known that in milling gear blanks a certain allowance must be made before the cutter cuts to the full depth, and that this must be added to the face when figuring the cutting time. The accompanying diagram and table show just how much this extra travel is. For example, the distance x is shown, in the accompanying table, to be 1.052 inch for a five-pitch cutter, 3 inches in diameter. This amount must, therefore, be added to the face of the gear to get the full travel required.

There is nothing difficult about the method of figuring, as it requires only the solution of a right-angle triangle in which the hypotenuse R represents the cutter radius; $R - (d + f)$, the perpendicular; x, the base of the triangle; $d + f$, the whole depth of the tooth. In the example given, the cutter radius is 1.5 inch. For a five-pitch cutter $d + f$ is 0.4314; therefore

OVER TRAVEL OF CUTTER WHEN MILLING GEAR TEETH



Cutter Diameter, Inches	Diametral Pitch of Cutter							
	4	5	6	7	8	9	10	12
4¼	1.414	1.353	1.184	.....	.....	.....	.....	.....
3⅞	1.342	1.219	1.124	.....	.....	.....	.....	.....
3¾	1.316	1.196	1.039	.....	.....	.....	.....	.....
3⅝	1.290	1.174	1.083	1.012	.....	.....	.....	.....
3½	1.263	1.150	1.062	0.991	0.934	0.884	0.842	0.773
3⅜	1.181	1.078	0.997	0.932	0.877	0.831	0.792	0.727
3	.....	1.052	0.974	0.911	0.858	0.814	0.775	0.712
2⅞	.....	.....	0.951	0.889	0.838	0.794	0.757	0.695
2¾	.....	.....	0.926	0.867	0.818	0.776	0.739	0.680
2⅝	.....	.....	.....	0.845	0.796	0.755	0.721	0.662
2½	.....	.....	.....	.....	0.776	0.736	0.702	0.646
2⅜	.....	.....	.....	.....	.....	0.715	0.682	0.627
2¼	.....	.....	.....	.....	.....	.....	0.663	0.610
2⅛	.....	.....	.....	.....	.....	.....	0.642	0.591
2	.....	.....	.....	.....	.....	.....	.....	0.572

$R - (d + f) = 1.5 - 0.4314 = 1.0686$; and $x = \sqrt{1.5^2 - 1.0686^2} = \sqrt{2.25 - 1.14188596} = 1.052. +$.

The table also shows the advantage of a cutter having a small diameter over one of larger diameter. Thus, in a five-pitch cutter, 4¼ inches in diameter, $x = 1.353$; whereas in a five-pitch cutter, 3 inches in diameter, $x = 1.052$, a difference of 0.3, so that on a number of gears the saving of time is considerable. Of course a table for keyway cutting could be arranged to show the amount of material cut into beyond the full depth of cut. The accompanying table is sufficient to cover most standard sizes of cutters. The over travel is given to the third decimal place for the sake of exactness, but of course the nearest thirty-second inch will be near enough for practical use.

Christchurch, New Zealand — PERCY W. FRAMPTON

MAKING A TAP FROM A WORN-OUT SCREW

In repairing machinery and machine tools, it is often necessary to make special taps. Lead-screws and nuts wear out, and in order to make a quick repair a tap corresponding to the lead-screw is necessary. Making a special tap for a repair job involves considerable time and expense. In one instance, the "man on the job" suggested converting the worn-out screw into a tap. The repair to be effected was the making of a new nut and screw for raising the grinding head on a Brown & Sharpe grinder. The old screw was perfect on one end for a distance of six inches; so this section was cut off, fluted, squared, hardened, and used to finish the new nut. This obviated the necessity of cutting a thread on the tap, and as the screw had an eight-pitch Acme thread, the operation would have consumed considerable time.

Jersey City, N. J. — W. H. DUNBRACK

CARE OF LATHE CENTERS

In a large shop where machines were not assigned to the workmen, it was found difficult to keep good centers in the lathes. A man finding the centers running out of truth would take one of them out, anneal it, turn it down so that it would run true, and finish his job, without stopping to harden the center. Oftentimes, what was originally the live center would be in a soft condition and in the tailstock of the lathe. As a result, much work was spoiled through the tailstock center being soft and burnt off, before the operator was aware of its condition.

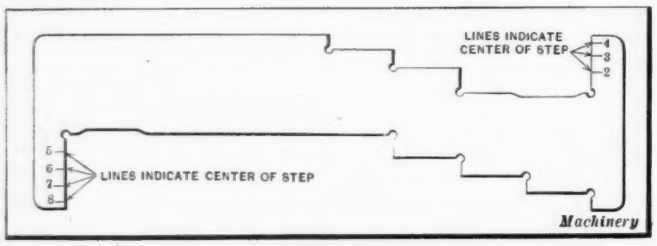
In some shops where similar conditions exist, it is common to find soft lathe centers because no center grinding attachment is available, or where there is one it may be in use and the men decide that it is quicker to anneal and turn a center true than to wait their turn for the grinder. In some cases, the centers have been taken out of one lathe and inserted into another, because the operator has carelessly burnt off the center. In others, much time has been wasted by men wandering around the shop until they found a lathe fit to be used; of course, after a man has centered his work at the proper angle, it is bad policy to try to turn it with centers of any angle.

In one shop, this difficulty of poor lathe centers was overcome by having two sets of centers for each machine, one being in the tool crib while the other was in use. Every lathe center was given the same number as the lathe it went into, and each live center had a scratch line that corresponded with a mark on the spindle of the lathe. When a man had lathe work to do, he procured his centers, in a good condition, from the toolroom attendant, and when he got through with the lathe he returned the centers and received his brass checks. If anyone carelessly burnt off one of the centers, the culprit was thus easily located. By this method good centers were always obtainable, and much time was saved.

New Haven, Conn. — ERIC LEE

INSIDE MICROMETER GAGE

The accompanying illustration shows a convenient gage for setting inside micrometers. The gage was made from machine steel, 3/16 inch thick, and after roughing down to within 0.015 inch of size was carbonized 1/32 inch deep. It was then hardened at 1420 degrees F., after being secured between two 1- by 3/8-inch iron bars. These bars prevented the gage from bending and kept the center practically soft; there was, however, an expansion of 0.005 inch in the length. In finish-grinding, size blocks were used, which made it possible to work to a close limit. The steps were ground first, as near to size as possible, and about 0.002 inch was left on the base until the steps were lapped to size, or, in other words, exactly 1 inch apart. Then the base was ground to the finished size. This gage is light and takes up little room in the tool-box. By its use, an instrument having a 1/2-inch adjustment can be set from 2 to 8 inches. For example, if the micrometer is to be set to 3.400 inches, the three-inch step on the gage is used, the thimble first having been set to 0; then the thimble is adjusted to 0.400 inch, giving the correct measurement of 3.400 inches. If the micrometer is to indicate 3.800 inches, it is set to the four-inch step, the thimble having been screwed out



Gage for setting Inside Micrometer

to 0.500 inch; the thimble is then screwed in 0.200 inch, giving the correct measurement of 3.800 inches.

Toronto, Canada. H. E. GOODGER

SPRING WINDING TOOL

A handy spring winding tool, shown in Fig. 1, consists of a strip *A* of common sheet steel with a hole at each end. The wire from the spool passes through the hole *B* at one end, over the strip, through a hole *C* at the other end, and thence around the arbor *D*. In this case, the operator uses his thumb to govern the tension, which he can do by placing it on the wire or on a small strip of leather that is riveted to the tool and is laid over the wire. The holes *C* should be drilled different sizes according to the diameter of the wire used and should allow about 0.02 inch clearance. They can be spaced to suit the conditions of standard springs and whenever a special spring is to be wound, the space between the coils can be calculated and a hole drilled in the strip the proper distance from

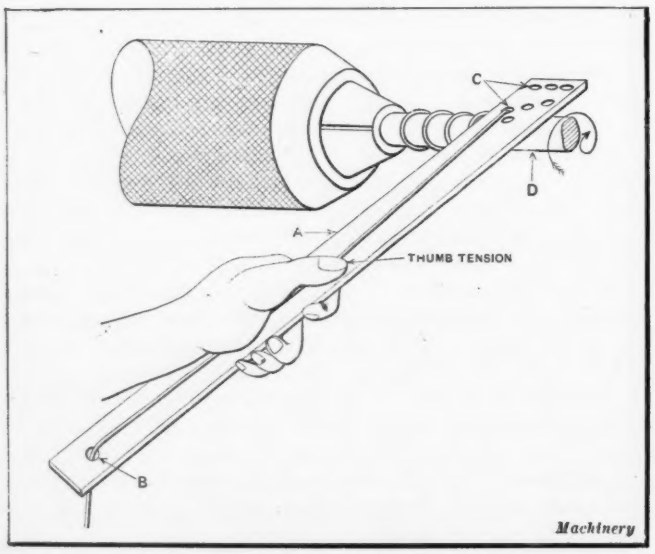
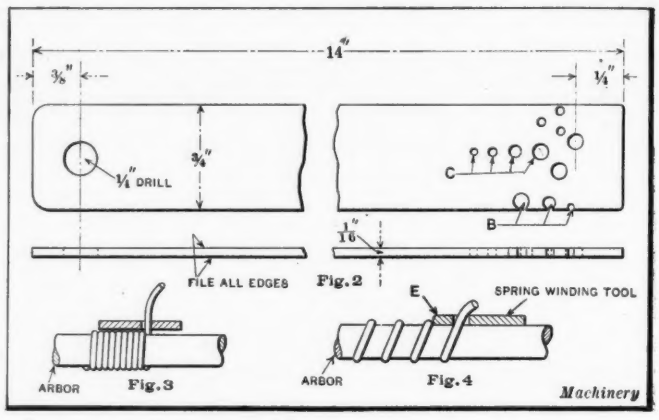


Fig. 1. Handy Method of winding Springs



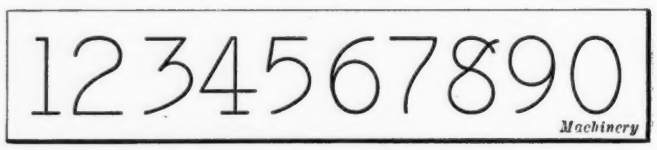
Figs. 2-4. Spring Winding Tool and Methods of using

either side of the tool. The side from which the dimension was taken should act as a guide *E*, Fig. 4. When a slight space is required, the tool is drilled and filed through the outer edge, as shown at *B* in Fig. 2. For close-wound springs, center holes *C* are used; the tool is then laid flat on top of the completed coils and a slight tension exerted sidewise toward the coils, as shown in Fig. 3. For open springs, the tool is held as shown in Fig. 4; the edge of the tool touches the last complete coil, which acts as a guide and gives uniform spacing.

Lynn, Mass. W. B. POHLE

PLAINER FIGURES FOR THE SHOP

When steel stamp letters and figures reach the well worn condition that seems to be typical in most machine shops, it is no wonder that the threes, fives, sixes and eights are often mistaken for one another. This is especially true when the surface upon which they are stamped is scaly or rough. The smaller the sizes of the figures, the greater is the likelihood of confusion, because the openings in the figures are less pronounced. The same condition holds true of pattern letters and figures. Of course, we all know that letters and figures should not be allowed to reach this condition without renewal, but the fact remains that they do.



Plainer Figures for the Shop

One large manufacturing concern has greatly improved matters by changing the form of the figures used. It will be seen in the illustration that the threes, fives, sixes and eights differ more than usual, having as large openings as possible in the formation. Since the adoption of this style of figures, mistakes in reading serial numbers, pattern numbers, etc., have been largely eliminated, and for this reason the same style of figures has been adopted for drafting-room use. C. L. L.

QUICK METHOD OF DRAWING ELLIPSE

The method of drawing an ellipse here shown eliminates all unnecessary construction lines which must be rubbed out after the ellipse has been constructed. It is not an exact geometrical construction, but is taken from the old method that has stood the test of time in nearly every drafting-room. The old method is as follows: On the major axis *AB* set off *AE* equal to *CD*, the minor axis, and divide *EB* into three equal parts. With *O* as a center and a radius equal to the length of two of these parts describe arcs cutting the major axis *AB* in *F* and *G*. Upon *FG* as a side construct two equilateral triangles *FHG* and *FIG*. With *H* as a center and a radius equal to *HD* describe the arc *JDK* intersecting *HG* and *HF* produced in *J* and *K*. With the same radius and with *I* as a center describe the arc *LCM* intersecting *IG* and *IF*

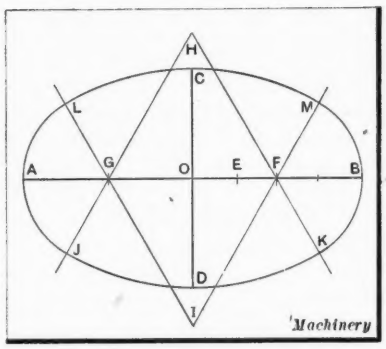


Diagram illustrating Quick Method of drawing Ellipse

produced in *L* and *M*. With *A* and *B* as centers and a radius equal to the chords of the arcs *AL* or *BM*, describe arcs cutting *AB* at the points *F* and *G*. From the points of intersection of these arcs with the line *AB*, and the same radius, describe the arcs *LAJ* and *MBK*.

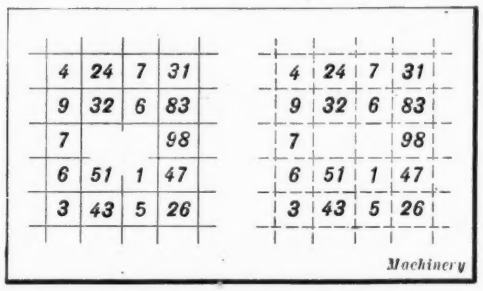
By the new method, let *AB* be the major axis, *CD* the minor axis and *DH* the radius for large arc on minor axis; then $DH = 1.15AB - 0.65CD$. After the large arcs are drawn, complete the ellipse by drawing an arc on the major axis tangent to the two large arcs and the ends of the major axis.

The accuracy of this method is shown by finding the value of *DH* from the old method: $OF = (AB - CD)\ 0.66$; $OH = OF \times \tan 60$ degrees; $DH = (OF \times \tan 60 \text{ degrees}) + 0.5\,CD$; $DH = [(AB - CD)\ 0.66 \times \tan 60 \text{ degrees}] + 0.5CD$. $0.66 \times \tan 60 \text{ degrees} = 0.66 \times 1.732 = 1.15$; $DH = [(AB - CD)\ 1.15] + 0.5CD$. By simplifying, $DH = 1.15AB - 0.65CD$. This formula checks back with a circle, as in a circle the major and minor axes are equal. For instance, take a circle 8 inches in diameter. *AB*, the major axis, = 8; *CD*, the minor axis = 8; *DH*, the radius of circle or arc = 4. The proof is $DH = 1.15\ AB - 0.65\ CD$; or $1.15 \times 8 - 0.65 \times 8 = 4$. The numerical coefficients of this formula are easily retained in the memory, by keeping in mind that $1.15 - 0.65 = 0.5$.

Brooklyn, N. Y. P. L. GADOL

RULING DATA SHEETS ON TRACING CLOTH

The writer often has to change information on data sheets, and in making the erasures has found that parts of the lines forming the columns were also erased. It was then necessary, after the change was made, to reink the erased parts of those lines, which seldom coincided with the lines already ruled in unless considerable care was taken. However, this trouble is easily avoided if the lines are ruled on the opposite side of the tracing cloth; that is, the information is put on one side and the lines on the other.



Erasures when Lines and Data are on Same and Opposite Sides of Cloth

New York City ANDREW F. BURGWALD

PENCILING DRAWINGS

A method of penciling drawings that makes them take on a clear-cut and finished appearance is to use two kinds of drawing pencils. A hard pencil (about 6H) with a wedge-shaped point is used for roughly laying out the detail, and for center and dimension lines, and a softer, or 4H, pencil with a round point is used for drawing in the solid or dotted lines of the detail and for arrowheads and lettering. By this plan a drawing can be easily traced, as there is a clear distinction between the lines, which gives almost the appearance of an inked paper drawing. The writer does not recommend this method of penciling for drawings such as assemblys upon which much time must be spent, as the soft pencil will cause the drawings to become smudgy, but for details, where the work can be traced quickly, or where the pencil drawing is shellacked and sent into the shop, the use of two pencils will be found well worth the small additional effort required.

Chicago, Ill. RALPH R. WEDDELL

MAKING A PRESSED STEEL COVER

The steel cover shown in Fig. 1 is made in two operations from 18-gage hot-rolled steel. It is then given a coat of black enamel. To eliminate trimming to length, the cover is made from a developed blank 3 17/32 inches in diameter. This is drawn into the cup shown at *A*, Fig. 1, on a compound blanking and drawing punch and die, Fig. 3. This cup is then put through an upsetting, perforating, and flanging die, Fig. 2, which produces the cover shown at *B*, Fig. 1. This is a finished article free from burrs and ready to go to the paint shop to receive a coat of black enamel.

The blanking and drawing die shown in Fig. 3 is more desirable for drawing shells that are afterward submitted to a finishing operation than is a double-action press. It produces a shell of uniform depth and height which is essential where no trimming is to be done. The punch-shoe *A* and the die-shoe *B* are made of cast iron and are aligned by steel guide-pins *C* and bronze bushings *D*. The blanking punch *E*, which also acts as a die, is made of hardened tool steel and is set in a counterbored shoe, being held in position by screws *F*. It has a spring knock-out pad *G*, which is actuated by a spring *H*. The blanking die, which is made of tool steel and

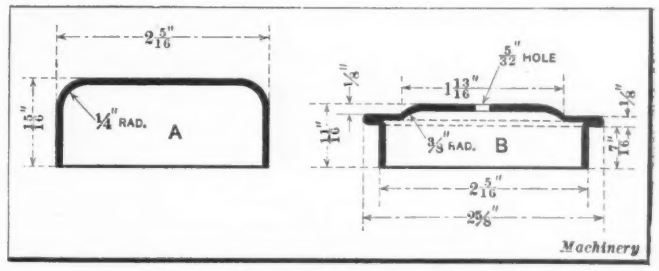


Fig. 1. Cup for Pressed Steel Cover and Finished Cover

is hardened and ground with plenty of shear, consists of a ring *I* that is set in die-shoe *B* and is held by screws *J*; *K* is the spacing gage. The forming punch *L* is held in position by a stud bolt *M*, which also holds in place rubber buffer *N* and pressure plates *O* with nut *P*. Rubber buffer *N* must be carefully adjusted when the dies are set up and care must be taken that excessive pressure is not exerted on pressure pad *R*, from the rubber buffer through pins *S*, as this would strain the metal or cause it to break or stretch. The stripper plates *T*, which are held by screws *V*, are made in two pieces and do not completely surround punch *E* while in operation; this is not in accordance with common practice. The top view is shown at Y–Y. This stripper is very satisfactory, as it gives the operator a good view and better command of his work. A channel *X* passes through the forming and drawing punch *L* and the stud bolt, then under the die to the opening *XX*. Its purpose is to eliminate suction while the shell is being stripped from punch *L*, making the stripping easier and causing less wear on the punch. Tapped holes *W* are provided for fastening the die to the bed of the press.

The flanging and perforating punch and die, Fig. 2, is

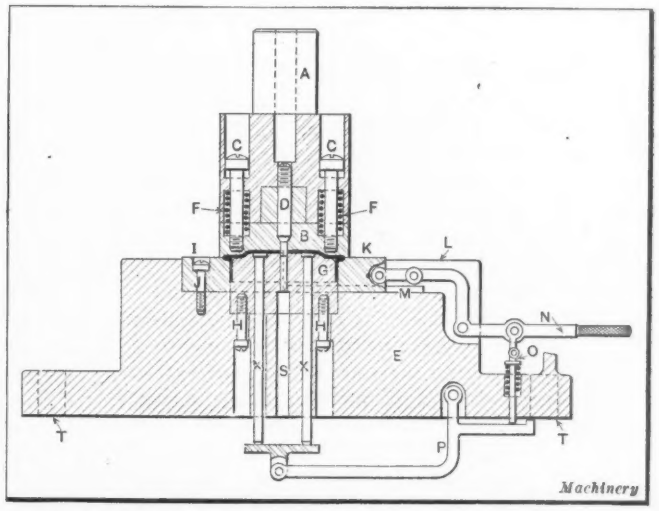


Fig. 2. Upsetting, Flanging, and Perforating Punch and Die

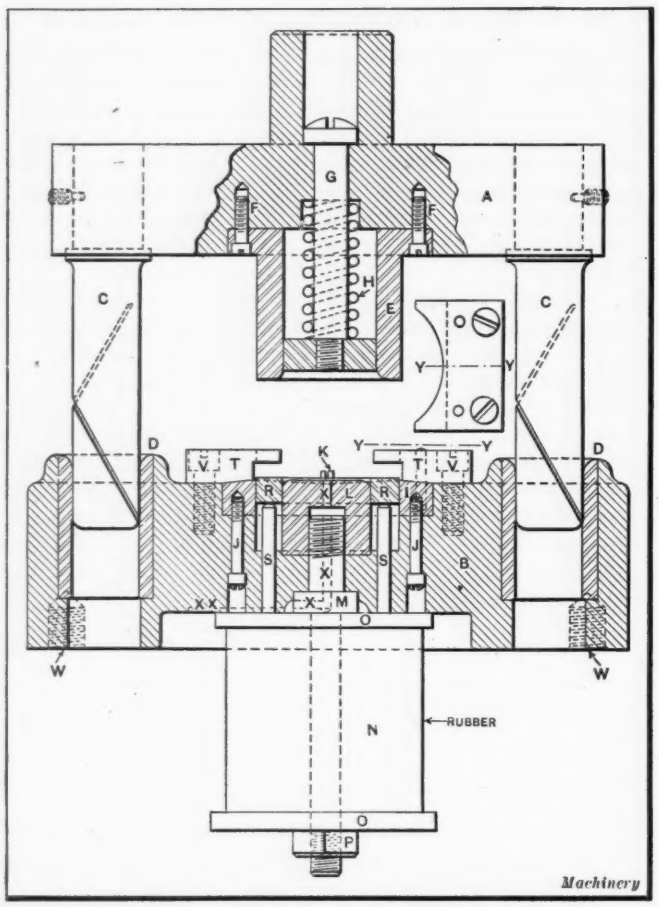


Fig. 3. Compound Blanking and Drawing Punch and Die for Steel Cover

shown closed with the finished cover in place. The punch *A* is made of machine steel and is counterbored to seat the tool-steel, hardened, working pad *B*, while under pressure. Pad *B* is held in place by screws *C*, which are ¼ inch long in order to allow the pressure pad ¼ inch movement from springs *F*. This movement releases the shell from the perforating punch *D* when the punch leaves the die on the upward stroke of the ram. The die-shoe *E* is made of cast iron and seats die *G*. The holes for screws *H* are elongated 1/16 inch to allow the die a forward motion of 1/16 inch, which is necessary when the die is open to give the proper freedom in placing or removing the shell. The rear flanging sections *I* are made of tool steel, hardened and ground and held stationary by screws *J*, while the forward section *K* moves horizontally in channel *L* and bevel gibs *M*. The front section *K* moves forward when the lever *N* is pressed down. At the same time, this lever, through stud *O*, causes lever *P* to raise knock-out pins *X* the proper height to discharge the cover, which is quickly removed and replaced by an unfinished shell. *S* is a channel for the discharge of slugs, and holes *T* are for fastening the die to the bed of the press.

Highland Park, Mich. ERNEST A. WALTERS

HELP FOR THE TOOL DESIGNER

Many of the largest factories whose systems are otherwise efficient neglect to inform the tool designer how many pieces are to be machined and what is the highest price that the fixture may cost, with the result that his designs for a jig or fixture may be rejected because of excessive cost. This cost, if three or four thousand pieces were to be machined, perhaps, would not be excessive, but in the case of a few hundred it might be unreasonable. With the larger number of pieces, the use of an automatic or semi-automatic device might be valuable because the saving of a few seconds on a piece would soon overbalance the increase in the cost of the jig. If the designer were given this information, there would be a great saving in designing time and in manufacturing costs, as there would be fewer cheaply constructed tools used on large orders and fewer overdesigned jigs on small orders

Detroit, Mich. LLOYD L. LEE

EMERY WHEEL ON MOTOR SHAFT

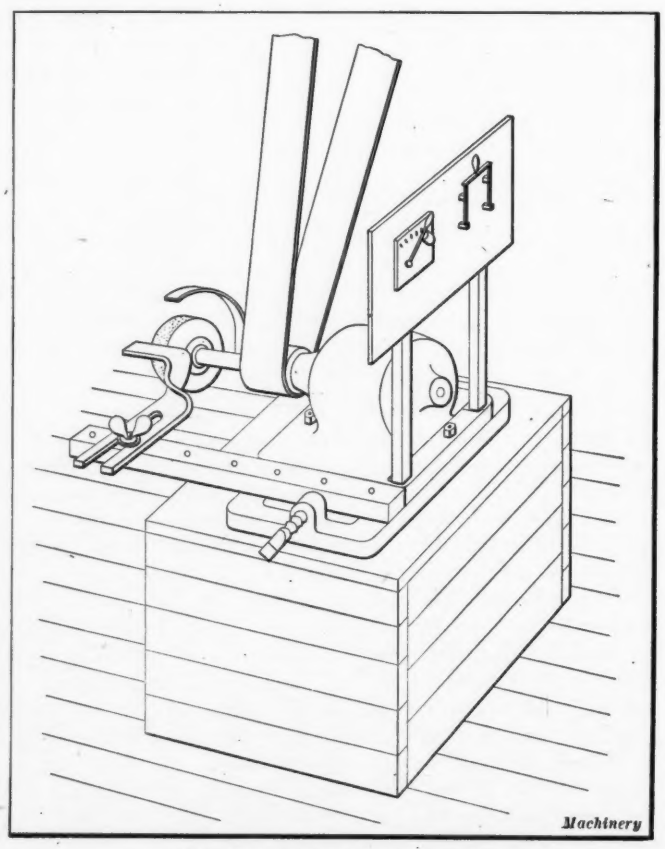
The little job shop with nine men and nineteen kinds of work for each man every nine hours cannot be expected to devote much time to stop-watch efficiency and motion study. Still the little shop does things that are well worth noting by mechanics who may be doing similar lines of work. In one small shop the writer has visited, several grinding machines are scattered through the shop—two or three ordinary stands of two stones each and one fine water-grinder. But because of the time required for the wheel to get up speed when starting an emery grinder, and as frequent trips to the grinding machine are necessary, an emery wheel has been set up on a motor shaft.

As shown in the illustration, the motor that drives the lathes was on a plank box of sufficient height to bring the shaft high enough for a grinder shaft. So an extension was fitted to the motor shaft on the pulley side of the motor and a 12-inch wheel with 1½-inch face, placed on it. The shaft extension is a piece of cold-rolled rod, a little larger than the motor shaft, which was fitted with a flange, collar, and nut to receive the grinding wheel; the opposite end of the extension was drilled and reamed to fit snugly over the motor shaft, the pulley of which was removed, bored out, and replaced outside of the motor-shaft extension.

The rest was attached to a 2 by 2 inch bar, which had evidently at some time done clamp duty on one of the planers in the shop. This bar was put on the base of the motor as shown, and held in place by means of the belt-tightening screw, which bore against the bar instead of against the motor base. After the motor bolts had been tightened, a turn of the belt-tightening screw exerted a vise-grip upon the rest-bar. The rest proper was forged from a bar of ½ by 2 inch black steel and was slotted and held in place by a wing nut, as shown. A guard was forged from another piece of flat steel and fastened with cap-screws to the rear of the sliding motor-base.

Although this device has been in daily use for more than five years, the dust and metal particles from the grinding operations have not done any damage whatever to either the motor or its bearings. The proper speed is there, the grinder never has to be stopped or started, and it consumes practically no power when not in use.

Another economical arrangement was the fastening of two



Attaching a Grinder directly to Motor

vertical angles to the sliding base and mounting a switchboard on these verticals. The knife-switch and the starting rheostat were located on this board, where they are convenient to the motor and to the workman who starts and stops it.

Indianapolis, Ind. JAMES F. HOBART

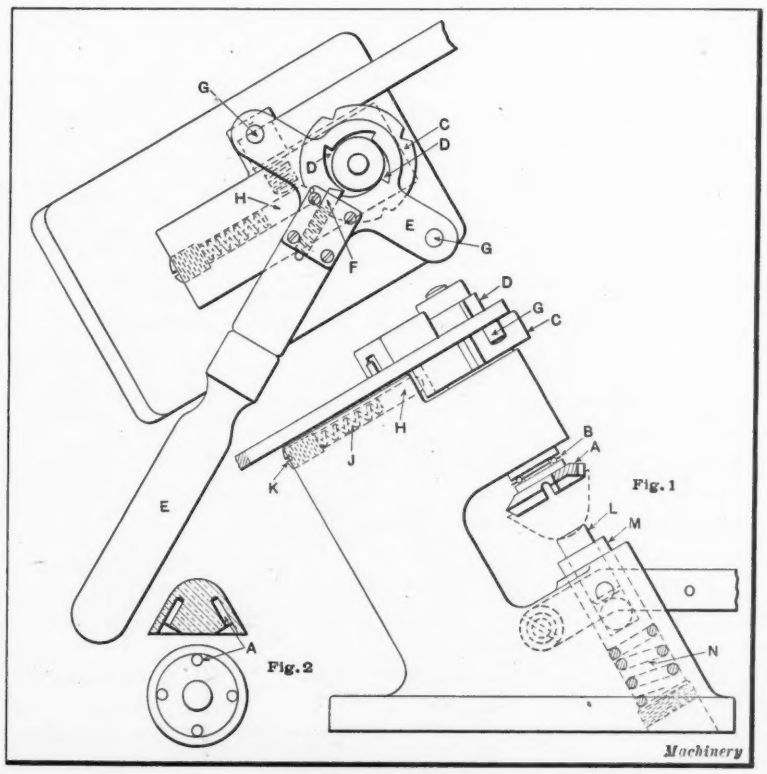
FAST INDEXING DRILL JIG FOR TIME FUSE CAP

The drill jig shown in Fig. 1 was designed for drilling four angular holes *A*, Fig. 2, in a brass time fuse cap. However, the principle can be easily applied to other work. The jig consists of a hardened steel locating plate *A*, Fig. 1, mounted on a hardened spindle, which runs in a bushing that is also hardened. A ball bearing *B* takes the thrust of the spindle. At the other end of the spindle is an index plate *C*, in which are cut four 90-degree notches. Keyed to the index plate, and also to the spindle, is a ratchet wheel *D*, having four teeth. A hand-lever *E*, which has a bearing and turns around a hub on the index-plate, carries a spring pawl *F* that engages with the ratchet wheel *D*. The lever also carries, at the outer ends, two pins *G* that project downward, so that when it is pushed back and forth the pins strike on the body of the jig and prevent carrying the index plate beyond the locking pin *H*. This locking pin is a hardened steel sliding pin, one end of which is rounded and engages with the notches in the index plate. Back of the pin and held in place by a headless set-screw *K* is a coil spring *J*, which holds the locking pin against the index plate. The tension of this spring is just enough to hold the work from turning while being drilled, but not enough to prevent its being readily indexed by a quick pull on the indexing lever.

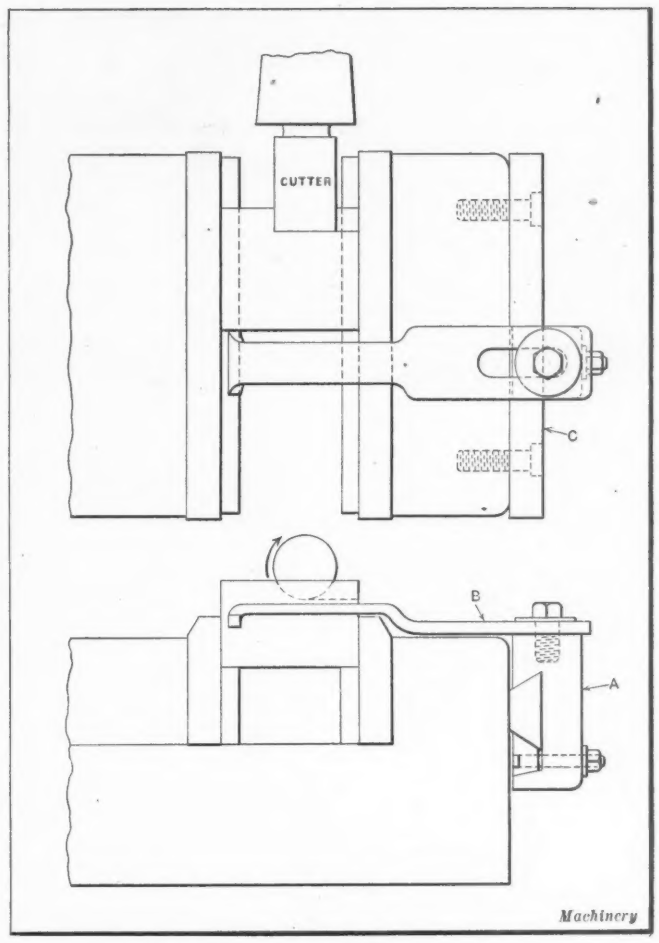
The work is held in position against the locating plate *A* by the plunger *L*, which rests on a single ½-inch hardened steel ball that acts as a bearing while the work is being indexed. Plunger *L* is carried in a second plunger *M*, which is held up by a powerful coil spring *N*. This spring should be longer and stiffer than the one shown, as an enormous pressure can be obtained with drills as small as the No. 30 used with this job. The outer plunger *M* is operated by a foot-treadle connected to the lever *O*. In operation, the foot-treadle is depressed and a piece of work is placed between the plunger *L* and the locating plate *A*. When the treadle is released, the work is held by the tension of the spring *N* while the indexing is done by the lever *E*.

The locating plate *A* has slots milled in it with a radius cutter of the same radius as the drill to be used. This feature, in connection with the lip on the work, answers the same purpose as a drill bushing, no other means of guiding the drill being necessary. The production of this jig is about 4000 caps per day.

New York City DONALD A. BAKER



Fast Indexing Drill Jig



Stop for locating Work in Milling Machine

VISE STOP FOR MILLING MACHINES

When a number of duplicate parts are to be machined, the vise stop here shown enables the operator to place each piece quickly in exactly the same location. The sliding block *A* and the finger *B* can be instantly adjusted to any position or removed when not in use. As the tongue *C* is never in the way, it can be left on the vise. The slot in the finger *B* allows it to be adjusted from the solid vise jaw to the position shown. The only strain on the stop is that from the hand holding the work against it and the solid vise jaw, which is square, until the vise is closed.

Beverly, Mass. V. G. TERRY

USING THE SLIDE-RULE

In the March number of MACHINERY, under the heading "Uses of Slide-rule," a method is given for setting the runner accurately to the decimal equivalent of a mixed number containing a common fraction. While the method gives the decimal value sought, it involves a mental calculation that may result in mistakes, and the estimate has to be made between 0.05-inch graduations, which may cause further discrepancy.

A more direct method, whereby the value may be read off directly within 0.0005, is to eliminate the integral and consider the fraction only. To find the decimal equivalent of 13/32 inch, set 32 on the C scale to the right index on the D scale, and under 13 on the C scale will be 0.4063 on the D scale. Any fraction may be solved in the same manner. To find the decimal of 24/39, set 39 on the C scale to the

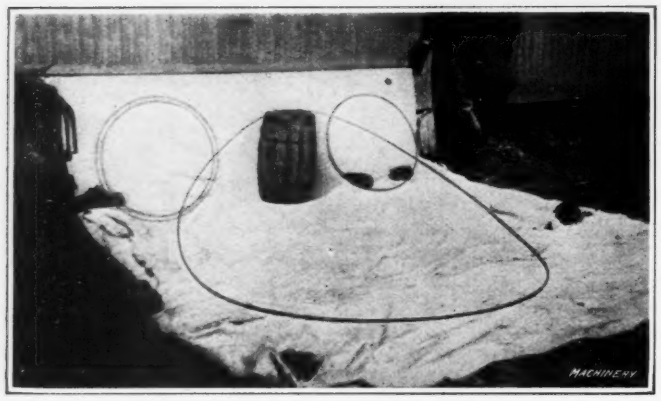


Fig. 1. Raise One Side Two or Three Feet

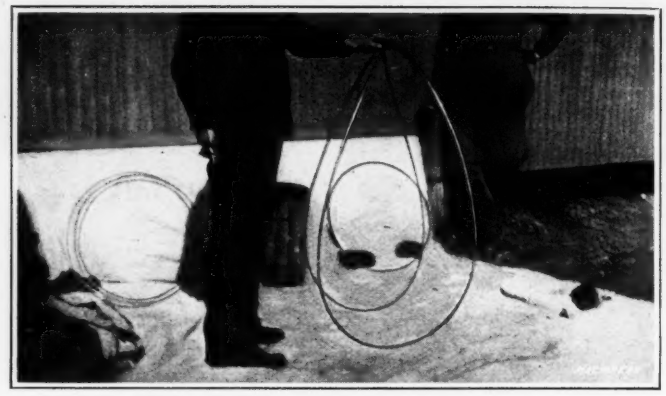


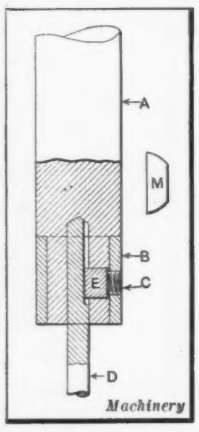
Fig. 2. Grasp Two Edges with Teeth Together

right index on the D scale, and under 24 on the C scale will be 0.6153 on the D scale. To convert a decimal into a fraction of any denomination, set the denominator of the fraction to the index, as before, and over the decimal on the D scale will be the numerator of the fraction on the C scale.

Bridgeport, Conn. A. C. HANNIBAL

SIMPLE DRILL CHUCK

In the February number of MACHINERY is an interesting article on "Drill Chucks." The following modification of one of the simple types of chucks described there may be of interest to some readers. One end of the spindle *A* is turned down to receive a collar *B* in which is a slotted-head set-screw *C*. In the end of the spindle is drilled a hole of the same diameter as that of the shank of the drill to be used. A slot is then cut across the spindle to a point a little less than half way through it. Block *E*, a plan of which is shown at *M*, is then fitted to this slot. The shank of the drill *D* is ground as shown. Chucks of this kind have been in use for a number of years on a multiple-spindle drill head and have proved very satisfactory where a high degree of accuracy is not required.



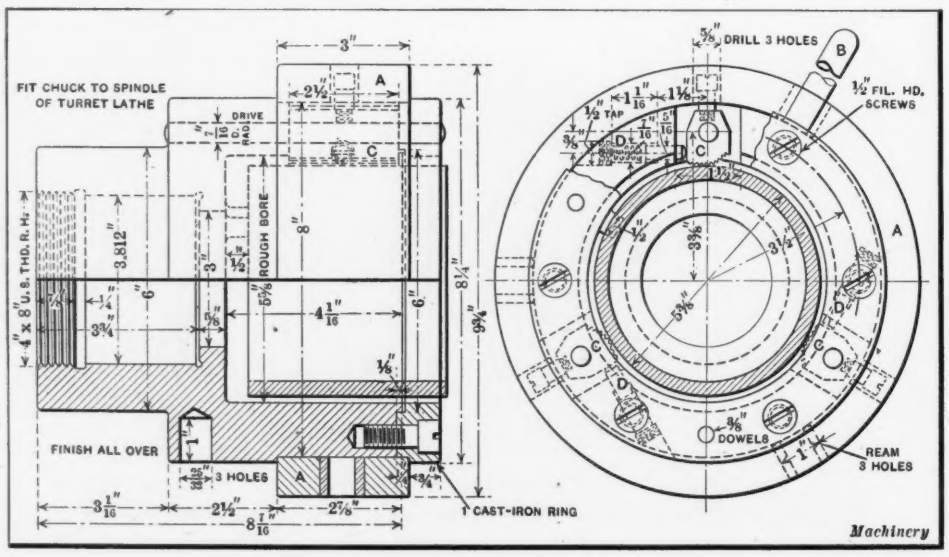
Simple Form of Drill Chuck

Beaver Dam, Wis. S. W. PALMER

QUICK-ACTING CHUCK

The accompanying illustration shows a quick-acting chuck designed for boring the inside of a steel tube. As the outside of the tube had only a small amount for finishing, it was necessary to bore the inside concentric with the outside. This chuck is made to fit a turret lathe or chucking machine. To open the jaws for inserting a tube, it is only necessary to revolve ring *A* slightly by means of pin *B*. This movement causes the jaws *C* to act against the pressure of the springs *D*. When the piece is inserted, the pin *B* is removed from the ring *A* and the springs *D* force the jaws to grip the work. The design of the jaws is such that the heavier the cut, the tighter will be the hold.

H. FRANCIS

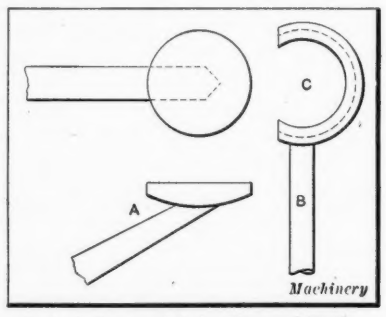


Quick-acting Chuck

MAGNETIZING PIECES THAT ARE TO BE SWEATED

In MACHINERY for February is described a method of preventing the slipping of two pieces of steel while being sweated together, to the value of which the writer can testify from experience. But he would like to add a hint for the benefit of anyone who has occasion to use this method with a magnetizing apparatus consisting of a coil of wire and an alternating current, as difficulty is sometimes met by men who do not understand the little peculiarities of the alternating "juice."

It is as easy to magnetize with alternating as with direct current if the switch is opened before the part is removed from the coil. The only difference is that with the alternating current no one can tell which end of the piece will be the north and which the south pole, as this depends on the direction of the current at the instant when the switch is opened. The writer has seen a man, after magnetizing one piece, repeat the operation twenty times on the other, getting the polarity wrong each time. Knowing that the chance of its coming right is "fifty-fifty," and misinterpreting, as so many do, the law of probabilities, he persevered in the full belief that the next attempt must be crowned with success. Finally, a neighbor suggested putting both parts into the coil at once with one part in a position opposite to that which it was ultimately to occupy, and his troubles were over.



Parts to be sweated together and Holder used while sweating

A somewhat interesting application of this idea of magnetic clamping once came to the writer's attention. A bronze part *A*, in the accompanying illustration, was to have a thin steel disk soldered to its flat surface. The shape of the bronze made it difficult to hold the pieces with even pressure in pliers, so that the disks were found to be tilted. A tool like that shown at *B* obviated this trouble. The tool-steel part *C* embraces a little more than a semicircle and is recessed to fit tightly on the bronze, the recess not being

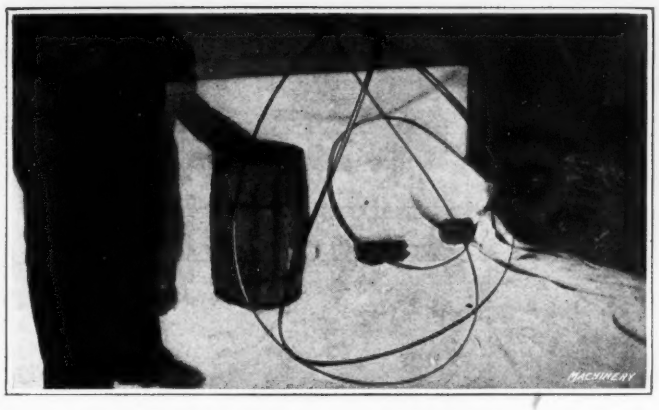


Fig. 3. Swing One Loop through the Other

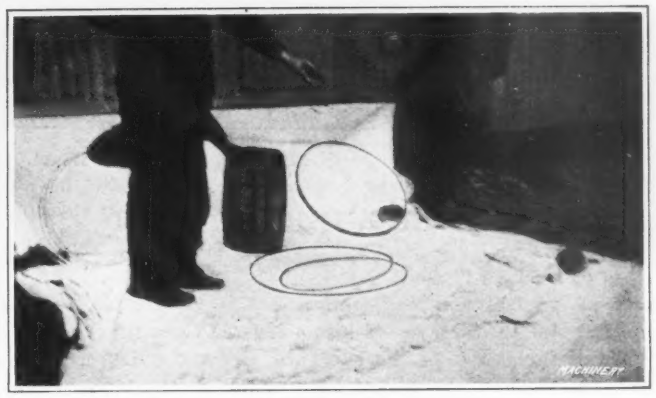


Fig. 4. Drop the Saw to the Floor

quite deep enough to allow its upper surface to come flush with that of the tool. The shank *B* is of brass and has a wooden handle on its outer end. One of the bronze parts, with its flat side already tinned, is placed in this holder, the steel disk is laid on top, and the holder and parts are inserted in the magnetizing coil. The disk is then turned 180 degrees and the sweating done.

New London, N. H. GUY H. GARDNER

MAKING BLUEPRINTS WITHOUT A TRACING

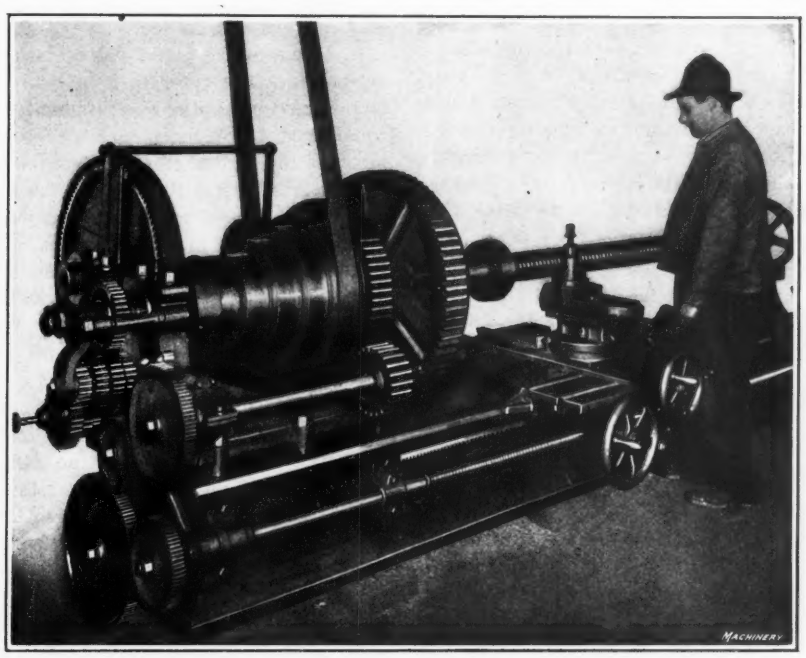
A good blueprint can be obtained from a soft-pencil drawing on a tough, light-weight bond paper. The method is useful when making shop fixtures, doing experimental work, etc., for the drawings can be readily changed, and, in experimental work, the drawings or prints can be used when making up the permanent tracings. The only disadvantage is that the drawings cannot be handled very much, because the soft-pencil lines rub off easily and the sheet soon becomes dirty. However, time is saved when only a few prints are required.

Beaver Dam, Wis. S. W. PALMER

LATHE ADAPTED TO CUT COARSE-PITCH SCREWS

An article appeared in the November, 1916, number of MACHINERY illustrating and describing how a lathe with a fine-pitch lead-screw was rigged to cut coarse-pitch screws. We used substantially the same scheme about thirty years ago in adapting an engine lathe that had a lead-screw with three threads per inch to cut coarse pitches. A jack-shaft was mounted on the front of the headstock, as shown, and was geared to the spindle gear in the ratio of 3 to 1. This gave us one inch movement of the carriage to one revolution of the spindle when two gears of the same number of teeth were mounted on the change-gear end of the jack-shaft and on the lead-screw. Movable studs were provided for mounting the intermediate gears, and provision was made for compounding. It will be noted that either right-hand or left-hand screws can be cut. The coarsest lead feasible to cut with this rig is about two inches. H. POTTS

Philadelphia, Pa.



Old Engine Lathe with Special Gear Train for cutting Coarse-pitch Screws

FOLDING A BAND SAW

To store band saws so that they can be handled easily, they should be rolled as tightly as possible. There are many ways of doing this, but unless one is skillful, there is danger of the saw kinking and injuring the person handling it. Fig. 1 shows a coiled band saw and another saw about to be rolled. The method of rolling is as follows: Raise one side, as shown, two or three feet with the teeth up; grasp the saw at about the center of the side opposite the raised part; carry this side over to the raised side, as in Fig. 2, and place the two edges with the teeth together. Raise the saw straight upward with the loops hanging down, the longer loop touching the floor, as in Fig. 3. Swing the shorter loop through the longer loop, at the same time dropping the saw to the floor. The saw will assume a circular position in three rolls, as in Fig. 4.

Moline, Ill. E. R. WIGGINS

COMB FOR DRAWING THREADS

Instead of using a thread pitch gage for spacing distances to lay out threads or cross-sections, I have found it convenient to use the ordinary comb with two sets of teeth. Simply ink the points of the teeth on an ink pad and press the comb on paper, and the spacing is instantly accomplished.

Bridgeport, Conn. JAMES MCINTYRE

THOUGHT VERSUS LABOR

In a shop where power presses were repaired, a shaft a half inch too long had been placed underneath the table of a press, so that the end came in contact with other working parts. It was therefore necessary to cut off the excess length. As the machine was assembled and it would have taken some time to take it apart, the parts that came in contact with the extra length of shaft were detached, and a slide-rest from a watch lathe was clamped to the under side of the press table. A belt was then run from the cone of a lathe over the press pulley and with a cutting-off tool inserted in the tool-holder the extra length was cut off the shaft. By this simple method, ten minutes' work saved taking the press apart and assembling it again, which probably would have taken twenty hours.

ERIC LEE

New Haven, Conn.

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

VANISHING THREAD JOINT

R. L. D.—What is a "vanishing thread" joint, and in what class of work is it used?

A.—A vanishing thread joint is a pipe joint made up of a tapered pipe thread screwed into a tapered thread socket. The taper of the thread is the standard pipe thread taper of 3/4 inch to the foot; the only difference lies in the fact that the thread is carried to the vanishing point instead of ending abruptly as is the case with commercial pipe threads. It is used for signal pipe and rotary drill pipe which require high tensile and torsional strength.

HOW TO PREVENT ACCUMULATION OF OIL ON MACHINE SHOP FLOORS

R. H.—I would like advice on means and methods of preventing an accumulation of oil on shop floors. The company with which I am connected has an automatic screw machine department using mostly cold-rolled steel stock, and cooling oil is used in the machines. Partly through the carelessness of the operators and partly through the carelessness of the men removing the chips, a considerable amount of oil gets onto the floor and is tracked all through the factory. The labor conditions are at present such that not much can be said to the men, as they quit on the slightest provocation. Sawdust on the floor has helped but little, and sweeping constantly would require too many laborers.

A.—The use of sawdust or shavings on the floor of screw machine departments is dangerous and is prohibited in many places on account of the increased fire hazard. The remedy in part lies in the use of well-fitted guards for preventing the oil from being thrown by the work from the machine, and in the use of convenient wheeled receptacles for the chips that enable the laborers to remove the chips from the chip pans without scattering on the floor. Systematic sweeping and mopping with alkaline solutions are necessary to keep the floors clean and free from slipperiness. The question is submitted to readers who have had success in overcoming the difficulty.

SOMETHING FROM NOTHING

J. B.—Fig. 1 shows a square measuring 8 inches on each edge. If cut into four pieces *M*, *N*, *P*, *Q* as indicated by the lines and dimensions, they can be rearranged to form a rectangle 5 by 13 inches, as shown in Fig. 2, by the full lines. Where does the extra square inch of area come from?

A.—We had supposed that it was universally understood and agreed that something cannot be obtained from nothing. Suppose that the square was a piece of steel plate, of a uniform thickness such that each square inch weighed one ounce, the entire plate weighing sixty-four ounces; then, according to the statement, by cutting and arranging the pieces as directed, they would weigh sixty-five ounces. If the plate were of gold or platinum, this would be a profitable operation, in fact it would be even better than a perpetual-motion machine; but as in such a case we would all be doing it, there would be nothing gained in the end. Many years ago someone told an English king that if a live fish were placed in a vessel of water, the vessel and its contents would weigh no more than it did before. The king referred the matter to his philosophers, who argued the question pro and con until the king was tired, so he ordered the matter to be settled by weighing the vessel and the water with and without the fish. In the present case, the question can be easily settled by making an accurate drawing of the pieces as rearranged. If the long sides of *M* and *N* are placed against the sides *AB* and *CD* of *P* and *Q*, the dotted lines show what the result will be. The edges *GH* and *IJ* overlap and their lengths are not equal to *EF*. In the question it is assumed that $AF + FB = 6 + 2 = 8$ inches; as a matter of fact, it is $\sqrt{5^2 + 6^2} = 7.81025$ inches. The question also assumes that the angle EDK = angle ABL, which is not true. Tan $EDK = 3/4 = 0.75$; tan $ABL = 5/6 = 0.833$; hence, ABL is greater than EDK. It is needless to say that the sum of the areas *M*, *N*, *P*, and *Q* subtracted from the area of the rectangle equals 1 square inch.

J. J.

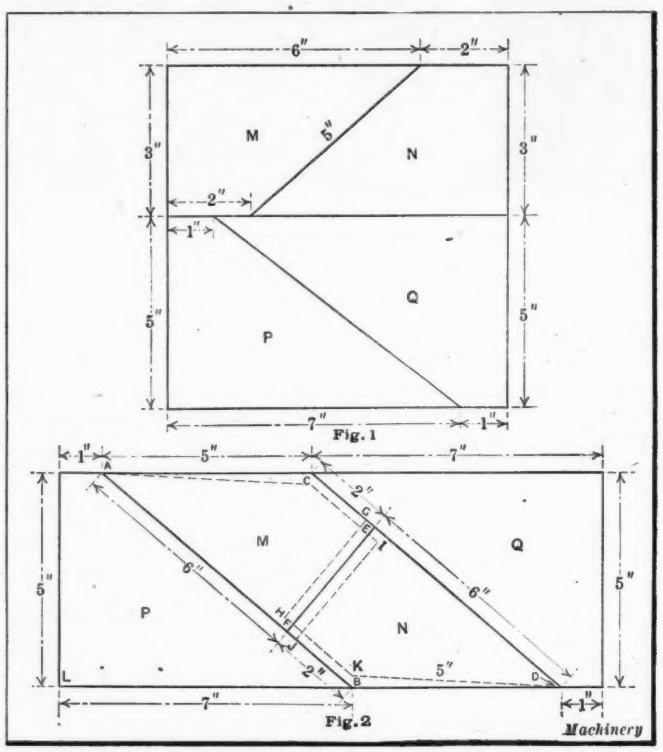


Diagram illustrating the Fallacy of obtaining Something from Nothing

MEANING OF "LATERAL" WHEN APPLIED TO MECHANICAL MOVEMENTS

U. M. C.—Has the word "lateral" a fixed and settled meaning in mechanics, and can it be applied to any other than a horizontal movement in a horizontal plane? Can it be applied to the movement of any body, whatever its shape? What relation does this word bear to the words "longitudinal," "vertical" and "horizontal"? Has it any meaning when applied to an object not in motion?

A.—Most of the principles of mechanics are founded on considerations that refer to a material particle and not to solid bodies having appreciable dimensions. When such bodies are considered, the discussion is generally restricted to the movement of the center of mass (center of gravity). Referring to the accompanying illustration, suppose that the rectangular prism is any solid body having any shape whatever, and that *O* is its center of mass. Through *O*, pass a horizontal plane $A_1B_1C_1D_1$, a vertical plane *ABCD*, and another vertical plane $A_2B_2C_2D_2$, intersecting the other two at right angles. The lines of intersection of the planes are MN, M_1N_1 and M_2N_2, each line being common to two planes and perpendicular to the third plane. Suppose that the body moves so that its center *O* always lies in one of these lines, say the line M_1N_1; then it will have no lateral movement. If, however, the body moves so that its center lies in the plane $A_1B_1C_1D_1$, the projection of its path on the plane $A_2B_2C_2D_2$ being the line M_1N_1, the body has a lateral movement with respect to the plane $A_2B_2C_2D_2$. Again, if the body moves so that *O* always lies in the plane $A_2B_2C_2D_2$, the projection of its path on the plane *ABCD* will be the line MN, and if *O* does not always lie in MN, the body has a lateral movement with respect to the plane *ABCD*. The body may also have a lateral movement with respect to the plane $A_1B_1C_1D_1$. It is evident from the foregoing that the word

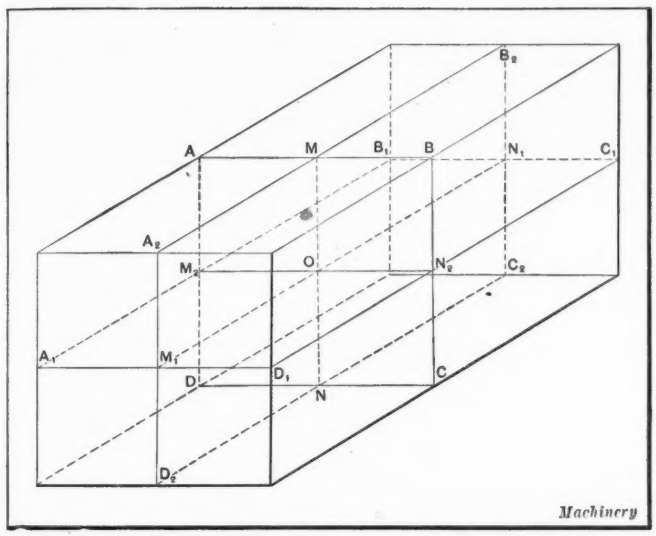


Diagram illustrating Meaning of "Lateral" as applied to Mechanical Movements

"lateral" can have no fixed relation to the words "longitudinal," "vertical" and "horizontal," but its meaning, as illustrated, is fixed and invariable. When applied to a stationary object, the upper and lower sides are called bases and the other sides are the lateral sides. Thus the lateral area of a prism is the total area exclusive of the bases—it is the area of the lateral sides. A house having a rectangular plan may be said to have a front and a back side and two lateral sides. Here "lateral" has a relation to the vertical, longitudinal plane. J. J.

STRENGTH OF A JIB CRANE

E. J. E.—The jib crane shown in Fig. 1 is loaded as indicated. Please advise if you would consider it safe without reinforcing the boom. A structural engineer advised me that a half-ton jib crane, having a boom 20 feet long, made of a 10-inch, 25-pound I-beam, was overloaded because the ratio of L/r was too high. A manufacturer of chain hoists illustrates, in his catalogue, a crane of the same length and size of beam, and rates it at 2 tons. There are a number of cranes of this type about the plant, and a difference of opinion has arisen as to where to draw the line for the proper safe loads. What is your opinion of Gordon's formula as applied to this case?

Answered by John S. Myers, Philadelphia, Pa.

The crane in question is similar to that shown in Fig. 2, reproduced from MACHINERY of March, 1908, where a similar problem is discussed by the writer. The sizes given for the present case are: $L = 25$ feet $= 300$ inches, and $H = 9$ feet $= 108$ inches. As the jib is made of a 10-inch, 40-pound, I-beam, area of section $A = 11.76$ square inches; flange width $b = 5.1$ inches; section modulus $Z = 31.7$; radius of gyration for lateral flexure $r = 0.9$ inch. The wheel-base is not given, but is assumed to be $B = 20$ inches. The loading is as follows:

	Pounds
Chain hoist capacity, 1½ ton	3000
Pull to raise load	110
Weight of hoist	130
Weight of trolley	175
Weight of one-half of beam	500
Impact, 25 per cent of above total	979
Total	4894

In round numbers, the total load $W = 4900$ pounds. It is not quite correct to include half the weight of the beam as if it were part of the moving load, but it simplifies matters.

Let M = bending moment under rear wheel;
D_r = distance to rear wheel from left support;
T = thrust on beam caused by angle of reaction;
S_b = bending stress due to wheel loading;
S = direct compressive stress due to thrust of tie-rod.

Then
$$M = \frac{WD_r}{L}\left(L - D_r - \frac{B}{2}\right) \quad (1)$$

$$S_b = \frac{M}{Z} \quad (2)$$

$$S = \frac{T}{A} = \frac{W}{HA}\left(D_r + \frac{B}{2}\right) \quad (3)$$

The combined stress in tension is $S_t = S_b - S$, and the combined compressive stress is $S_c = S_b + S$. This combined compressive stress S_c becomes maximum when:

$$D_r = \frac{LZ}{2HA} + \frac{L}{2} - \frac{B}{4} \quad (4)$$

Substituting values in (4), the location of the load for the maximum stress is found to be:

$$D_r = \frac{300 \times 31.7}{2 \times 108 \times 11.76} + \frac{300}{2} - \frac{20}{4} = 148.75, \text{ say } 149$$

The bending moment with this value of D_r is:

$$M = \frac{4900 \times 149}{300} \times \left(300 - 149 - \frac{20}{2}\right) = 343{,}000 \text{ inch-pounds}$$

The bending stress is $S_b = \frac{343{,}000}{31.7} = 10{,}820$ pounds per square inch. The direct stress is $S = \frac{4900}{108 \times 11.76} \times \left(149 + \frac{20}{2}\right) = 614$ pounds per square inch. The combined tensile stress in the lower flange is $S_t = 10{,}820 - 614 = 10{,}206$ pounds per square inch. The combined compressive stress is $S_c = 10{,}820 + 614 = 11{,}434$ pounds per square inch.

As only one flange is in compression, the total member is not a true column, because this flange receives some lateral support from the tension flange. A formula given in the Cambria Steel Co.'s Handbook for beams without lateral support, having the same general form as Gordon's formula, is:

$$S_c = \frac{18{,}000}{1 + \frac{L^2}{3000\,b^2}} \quad (5)$$

Here S_c = safe compression stress when the safe tensile stress is taken as 16,000 pounds per square inch. Applying this formula,

$$S_c = \frac{18{,}000}{1 + \frac{300^2}{3000 \times 5.1^2}} = 8360$$

The actual maximum stress is 11,434; hence the beam is loaded to a stress corresponding to $\frac{11{,}434}{8360} \times 16{,}000 = 21{,}900$ pounds per square inch. The apparent factor of safety based upon 64,000 pounds ultimate is then $64{,}000 \div 21{,}900 = 2.92$, which is an inadequate margin. Hence, for this condition of loading, the compression flange should be reinforced or braced laterally.

If this were a simple boom with the load applied at the extreme end, as in Fig. 1, the thrust induced by the tie-rod would be:

$$T = \frac{WL}{H} = \frac{4900 \times 300}{108} = 13{,}600 \text{ pounds}$$

The direct stress is then $S = 13{,}600 \div 11.76 = 1156$ pounds per square inch. The member is now a pin-ended column, the ultimate compressive strength per square inch for which is, according to Gordon's formula:

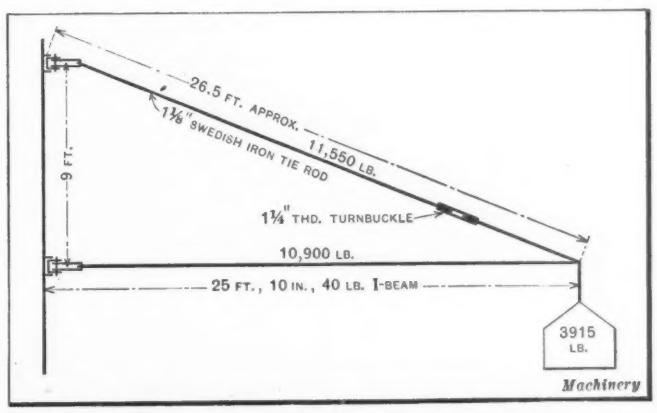


Fig. 1. Diagram illustrating Jib Crane, the Strength of which is to be determined

$$P = \frac{50{,}000}{1 + \frac{L^2}{18{,}000\,r^2}} \qquad (6)$$

For this case, $P = \dfrac{50{,}000}{1 + \dfrac{300^2}{18{,}000 \times 0.9^2}} = 6970.$

The factor of safety is, then, 6970 ÷ 1156 = 6.03, which is apparently ample for this condition of loading. But the "slenderness ratio" of the strut, that is, the ratio $\frac{L}{r}$, is 300 ÷ 0.9 = 333, which, as viewed by structural engineers, is not a permissible value. This is the real point of controversy—a mooted question which, it would seem, has not been as much discussed as its importance warrants.

Applying Euler's formula, $P = n\pi^2 E \frac{I}{l^2}$,

in which P = critical load, or the load that, acting with a continually increasing lever arm as the column deflects, will cause failure by buckling;

E = modulus of elasticity;

I = rectangular moment of inertia;

l = length in inches;

n = coefficient to take account of condition of ends.

As E = 29,000,000, I = 9.5, and n = 1, $P = 1 \times 3.1416^2 \times 29{,}000{,}000 \times \frac{9.5}{300^2} = 30{,}212$. The factor of safety is then 30,212 ÷ 13,600 = 2.22, a very small margin. Had the extreme case of n = 1/4 been taken, the critical load would have been less than the actual load.

The subject of compression members, in general, is rather unsatisfactory from a technical point of view, inasmuch as it is somewhat allied to the laws of chance, which are not supposed to have any place in the engineer's creed. Briefly stated, the salient points are about as follows:

Short compression members of compact cross-section, centrally loaded, fail by pure crushing or by shearing on an oblique plane.

Short compression members eccentrically loaded fail when the combined bending and compressive stresses reach the yield point.

Long columns, if absolutely perfect, should, in theory, fail in a similar manner; but owing to such imperfections as nonhomogeneity of material, uncertainty as to absolute centrality of loading, accidental lateral stresses, etc., they collapse at or above some critical load, which depends largely on the slenderness ratio. Euler's formula is conceded to give this critical load for such columns.

The slenderness ratio L/r at which such failure occurs is usually conceded to lie between 100 and 120, but for struts very lightly loaded or redundant members, this ratio is often taken as high as 180 or 200.

Compression members that are lightly loaded but that have ratios of L/r exceeding these values may never actually fail, yet an element of chance is involved that no conscientious designer wishes to count upon when failure may mean loss of life.

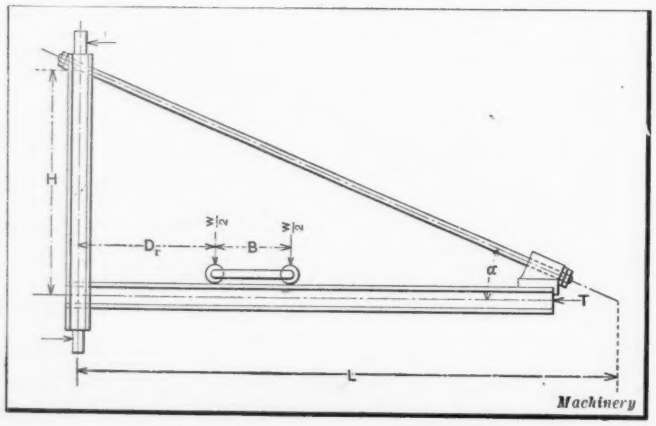


Fig. 2. Jib Crane supporting a Moving Load

Columns of built-up section usually fail by local buckling of some element of the section; the whole is thus weakened and total collapse follows.

Beams subject to combined flexure and compression are not true columns when one flange is in tension, because this flange lends lateral support to the compression flange.

As built-up columns fail by local buckling, a method of treating slender columns of such shapes as I-beams, when slightly loaded, would be to consider the load as carried by the flanges alone, in which case the radius of gyration is:

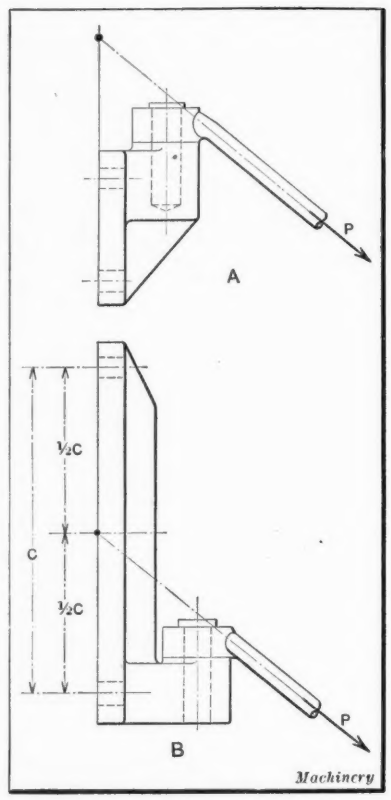


Fig. 3. Eccentrically Loaded Crane Attachments

$$r = b/\sqrt{12} = 0.289\,b \qquad (7)$$

Here b = breadth of flange.

Treating the present problem, for the condition of load applied at the end, in this manner we have the following:

As flange area is approximately 5.27 square inches, $S = \frac{T}{A} = \frac{13{,}600}{5.27} = 2580$ pounds per square inch.

The radius of gyration of the flange alone is $r = 0.289 \times 5.1 = 1.47$ inch.

Then $$P = \frac{50{,}000}{1 + \frac{300^2}{18{,}000 \times 1.47^2}} = 15{,}090$$

The factor of safety is then 15,090 ÷ 2580 = 5.84, and the slenderness ratio is $\frac{L}{r} = \frac{300}{1.47} = 204$. This is a considerably higher value than what is generally considered good practice, so that, while the apparent margin of safety is ample according to this treatment, there is the element of chance as to erratic behavior of such a slender member, and it would be well to reinforce or laterally brace the compression flange.

A frequent source of danger in poorly designed cranes of this variety is to be found in eccentrically loaded attachments. The writer has in mind constructions embodying the principle indicated at *A* in Fig. 3. Here the patternmaker and the blacksmith who built the crane supposed that the pull P is equally divided between the four bolts holding the bracket to the post, as it would have been had the bracket been constructed along the lines indicated at *B*.

Many examples of long compression members are to be found in engine valve gears. Some of these members, made thirty-six years ago, are intact today. On a high-speed engine, the steam-valve driving rod is 114 inches between centers and 1¾ inch in diameter. According to Euler's formula, the critical load is about 10,000 pounds, and according to Gordon's formula, about 25,000 pounds. The ratio of slenderness is L/r = 261; and while this ratio seems excessive, especially where there is vibration, as the actual load is light, no trouble is experienced. This does not say, however, that it is good practice, and later designs have been made of tubing with a lower slenderness ratio.

EPICYCLIC GEAR TRAINS[1]

FUNDAMENTAL PRINCIPLES, FORMULAS AND COMMON APPLICATIONS

BY REGINALD TRAUTSCHOLD[2]

AN epicyclic gear train consists of a number of meshing gears, of which at least one revolves around a central gear, at the same time rotating about its own axis, so that the arm or bracket supporting such planetary gear, or gears, is given a definite speed of rotation by the driving gears. When the arm or bracket is the driving member of the combination, it imparts a definite speed to the driven gear, any intermediate gears or pinions simply acting as members for the transmission of motion between the principal parts—the driving and driven members of the combination. Obviously, the arrangement offers possibilities of securing high speed ratios with comparatively few gears, compactly disposed and of extremely quiet and smooth operation, the various gears being in constant mesh, thus minimizing the shock of impact between teeth. It lends itself to many transmission problems that would otherwise be solved with difficulty and require cumbersome gearing.

Adaptable and convenient as are epicyclic gear trains, their use has been largely limited to certain types of speed reducers, and special, intricate machines or mechanisms, etc.,

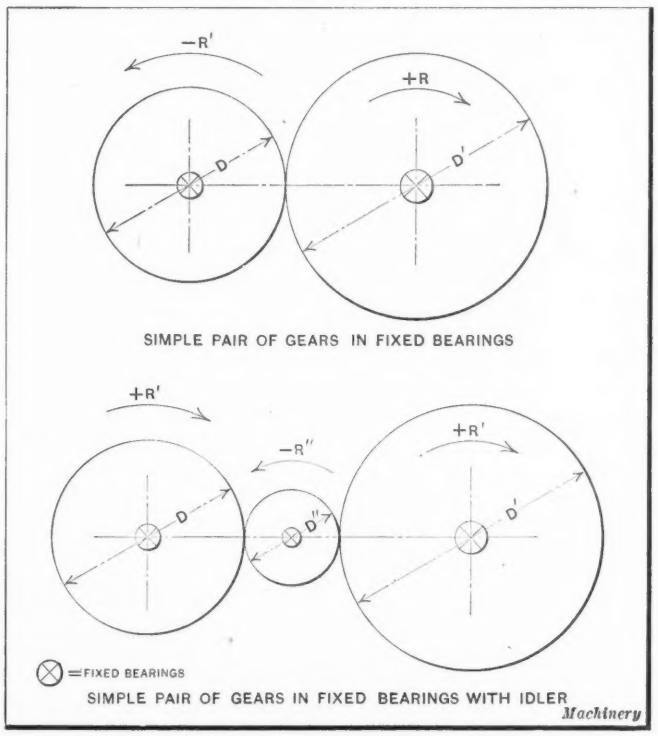


Fig. 1. Diagrams of Simple Gear Combinations

chiefly on account of the failure of designers to appreciate their adaptability. This is largely due to the complexity of the calculations—largely fancied—involved in their design and results in the frequent selection of more cumbersome, but more familiar gearing. The gear designer is only partly responsible for the limited use of epicyclic gear trains, however, as a general lack of familiarity on the part of possible users of such mechanism is the chief factor retarding their more general use. The individual gears comprising an epicyclic train are not at all special; they are customarily of the ordinary spur type of comparatively fine pitch. But it is in failure to clearly comprehend the action of the gears when in operation that there is likely to be confusion which so often results in the avoidance of the mechanism in general practice. A clear understanding of the principles of an epicyclic gear train simply necessitates familiarity with the action of ordinary gearing in fixed bearings. Such gearing may be simple or compound. It may consist of a train of gears mounted

[1] For additional information on the design of gearing, see "Internal Worm-gearing" in the April number of MACHINERY, and articles there referred to.
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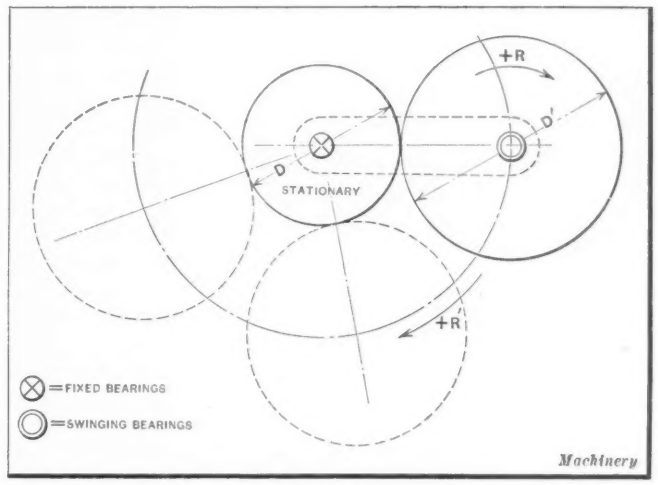


Fig. 2. Simple Epicyclic Train

on individual shafts, or a train in which at least two of the gears are connected so as to rotate as one unit, that is compounded. If of the latter type, the mating gears may be mounted on separate shafts, or if on the same shaft they must be free to rotate independently of one another.

Simple Gear Trains

Fig. 1 illustrates diagrammatically two simple gear combinations. One is a simple pair of gears in fixed bearings, the respective speeds of which are inversely proportional to their diameters, or the number of teeth which they contain; the other is a train of three gears, similarly mounted, the speed of the end gears of which bear the same relation to their respective diameters as does the train of two simple gears in fixed bearings. The only difference in the two arrangements, as far as the rotation of the effective members is concerned, is that the two simple gears turn in opposite directions, one clockwise (+) and the other counter-clockwise (—); while in the train of three gears the end gears—the driving and driven members—rotate in the same direction and the intermediate gear, or idler, alone turns in the reverse direction.

Any number of intermediate gears can be added to such a simple train without affecting the relations of speed and diameter between the end gears; the effect produced by the interposed gears is simply the regulation of the direction of rotation of the effective members. When the number of gears in the train is even, the end gears revolve in opposite directions; when the number of gears is odd, the effective members turn in the same direction. The velocity ratio of the smaller

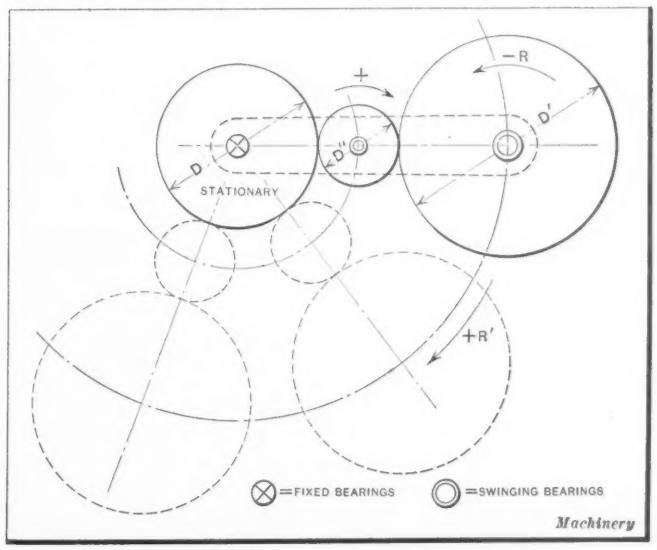


Fig. 3. Simple Epicyclic Train with Idler

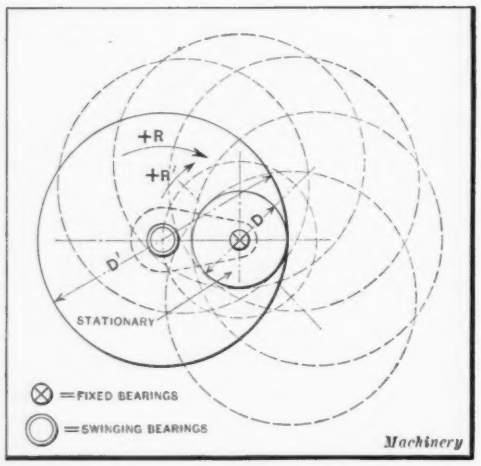


Fig. 4. Simple Internal Epicyclic Train with Arm Driving and Pinion Dead

end gear to the larger end gear is equal to the larger gear diameter divided by the smaller gear diameter.

The substitution of an internal gear for one of the externally meshing end gears does not affect the speed relationship of the train, but does alter the direction of rotation of the end members. The direction in which an internal gear, meshing with a simple pinion, will turn is the same as that of the pinion, and the interposition of any odd number of idler gears simply reverses the direction of rotation. That is, the direction of rotation of an internal gear actuated by an even number of gears is always opposite to that of the first of the gears, and for one running with an odd number of gears, the direction of rotation is the same as that of the first of the gears. It is these simple relationships between the diameters and speeds of meshing gears and the important consideration of direction of rotation that govern the action of simple epicyclic gear trains.

Simple Epicyclic Gear Trains

The simplest epicyclic arrangement of externally meshing gears is that shown in Fig. 2. It consists of two simple gears in mesh, one of which is mounted on a fixed bearing, while the other is in a floating bearing, which may be swung about the center of the first gear; the floating, or swinging, bearing is supported by an arm as indicated. In its elemental form, the central gear, the one mounted on fixed bearings, is stationary, or a dead gear, and the driven gear and the driving arm are the rotating members.

To arrive at the rotary speed of the driven gear, in terms of the speed of rotation of the driving arm, two independent motions must be considered: first, that which the driven gear has by reason of its rotation about the center of the dead gear; and second, that which is imparted to the driven gear by being forced to roll about the central gear. In the first instant, considering the driven gear as fixed—that is, held in the driving arm so that it cannot revolve on its own axis but slipped out of mesh with the dead gear so that it can revolve with the arm—for each revolution of the driving arm any given point on the driven gear will make a revolution about the dead gear, which, as far as the driven gear is concerned, is equivalent to a revolution about its own axis in the same direction as that in which the driving arm revolves, the gear remaining stationary. In the second instant, considering the driving arm as fixed, the rotary speed that will be imparted to the driven gear in rolling about the dead gear is the same as would be imparted to it by a revolution of the central gear in a reverse direction while the driving arm remained stationary. The rotary speed of the driven gear in actual operation is then the sum of these two motions, or is equal to the rotary speed of the driving arm multiplied by one plus the quotient of the diameter of the stationary dead gear divided by the diameter of the driven gear.

The interposition of an idler, or any odd number of idlers, between the dead and driven gears, as shown in Fig. 3, causes the driving arm and the driven gear to revolve in opposite directions and materially affects the relationship between the rotary speeds of the driving arm and driven gear, the first gear, as before, being dead. The revolution of the driven gear about the dead gear, with the driving arm, is equivalent to a revolution of the driven gear in the same direction as that of the driving arm, but the rotary motion imparted to the driven gear by virtue of its rolling about the dead gear is reversed through the agency of the interposed idler, so that the rotary speed of the driven gear is equal to the sum of a positive motion and a negative one. That is, the rotary speed of the driven gear is equal to the rotary speed of the driving arm multiplied by one minus the quotient of the diameter of the dead gear divided by the diameter of the driven gear.

A simple epicyclic train with an odd number of idlers presents an interesting arrangement of gearing, for, if the driven gear is of the same diameter as the dead gear, no rotary motion will be imparted to the driven gear, no matter how speedily the arm might be revolved. The driven gear will travel with the driving arm, on which it is mounted, but the location of any point on its circumference, in reference to its axis, will remain constant. Should the driven gear be the larger, its rotation on its axis will be in the same direction as that of the driving arm; while, if the dead gear is the larger, its direction of rotation will be reversed. This gives a wide range of speed and the possibility of securing a high speed ratio, with but a comparatively small variation in the sizes of the effective members.

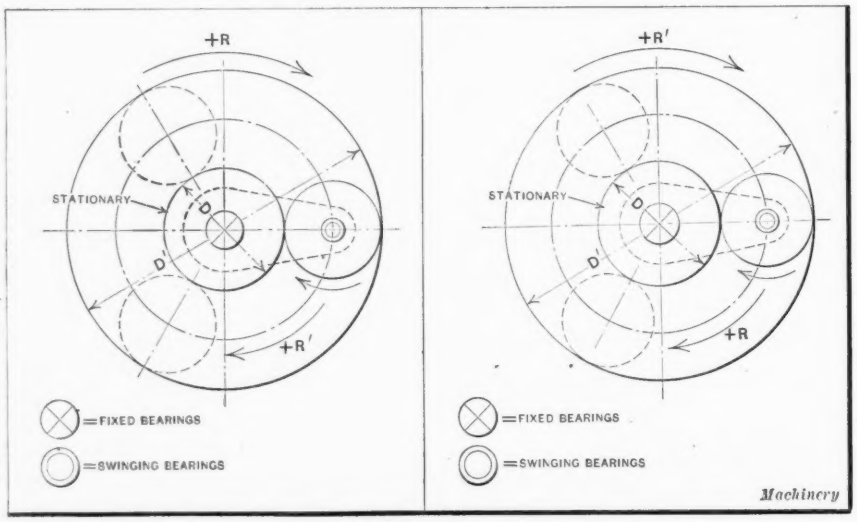


Fig. 5. Simple Internal Epicyclic Train with Planetary Pinion—Arm driving and Central Gear Dead

Fig. 6. Simple Internal Epicyclic Train with Planetary Pinion—Internal Gear driving and Central Gear Dead

The two foregoing arrangements, representing elemental, or basic, types of epicyclic trains, have quite limited use, for the driven gear is mounted on a swinging shaft and the effective use of its rotary speed is a difficult matter, unless the train is used as a transmission medium in more complicated mechanisms, an example of which will be analyzed subsequently.

Simple Internal Epicyclic Gear Trains

In Fig. 4 is shown a simple internal epicyclic train of two gears in which the pinion is the dead gear and the arm that carries the internal gear on swinging bearings is the driving member. Obviously, the internal gear has two independent motions, namely, rotation about the stationary dead gear with which it is held in mesh by the driving arm, and rotation about its own axis.

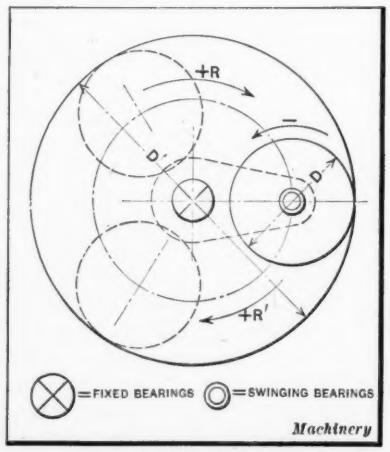


Fig. 7. Simple Internal Epicyclic Train with Arm driving and No Dead Gears

Considering the driven gear as fixed, a revolution of the driving arm, were that possible, would cause the driven gear also to make a revolution in the same direction. With the driving arm fixed and the stationary gear freed so it could make a revolution in a direction opposite to that of the driving arm—the direction in which it would revolve during the rotation of the driving arm were it free to do so—the driven gear (internal gear) would be rotated in a direction opposite to that of the driving arm by that part of a revolution measured by the quotient of the diameter of the dead gear divided by the diameter of the internal gear. The sum of these independent motions, the rotary speed of the driven gear, is equal to the rotary speed of the driving arm multiplied by one minus the quotient of the diameter of the stationary gear divided by that of the internal gear.

This arrangement of gears, like the simple epicyclic trains composed exclusively of externally meshing gears, has the disadvantage, for many services, of non-concentricity of driving and driven members; that is, the rotary path of the driven gear is not concentric with the revolving path of the driving arm, or *vice versa*. With the internal gear arrangement, however, this can be overcome without the necessity of additional parts or other complication of the mechanism. By making the pinion active instead of dead, the bearings of the internal gear fixed instead of swinging, and the pinion bearings of the floating type instead of fixed, as in Fig. 7, the rotating arm and the internal gear continue to be the effective members, and there is no change in the relationship of their respective speeds of revolution, no possibility of other motion being introduced. The rotary paths of the driving and the driven members are then concentric, and the construction can be used as a simple and effective speed reducer between two aligned shafts.

As the diameter of the pinion is less than that of the internal gear with which it meshes, the direction of rotation for the driving and the driven members in the two latter arrangements of epicyclic gear trains must always be the same; and, by making the diameter of the pinion as large as possible, high speed ratios with but two gears can be secured. When the pinion is small in comparison with the internal gear, the speed ratio is small, and it frequently becomes advisable to use several such planetary pinions—such an arrangement being shown in Fig. 7—in order that the pinions, with their comparatively high speed of revolution, will not be overloaded. In such cases the driving arm is replaced by a driving bracket carrying the necessary number of pinions mounted in fixed relationship on a concentric circumference of swinging bearings. Any number of pinions for which there is sufficient accommodation may be installed without in any way affecting the speed ratio of the mechanism, for the pinions simply distribute the load.

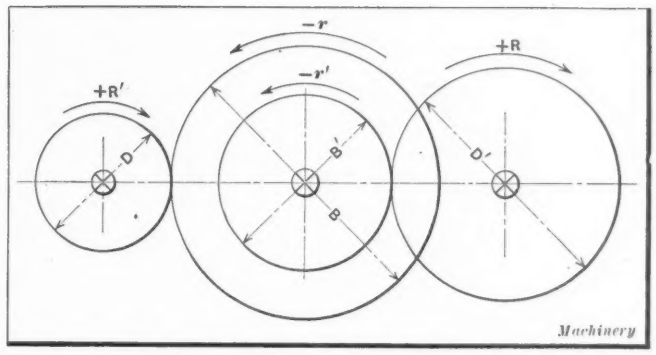


Fig. 9. Simple Gears in Fixed Bearings with Intermediate Compound Idler

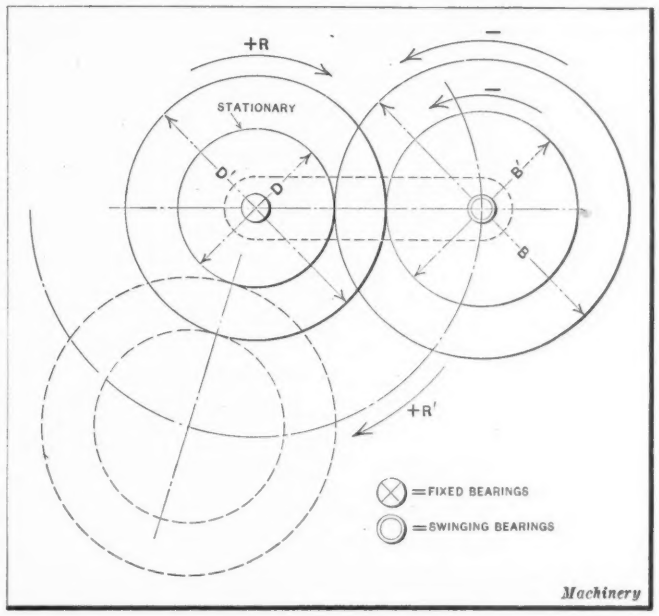


Fig. 10. Compound Epicyclic Train

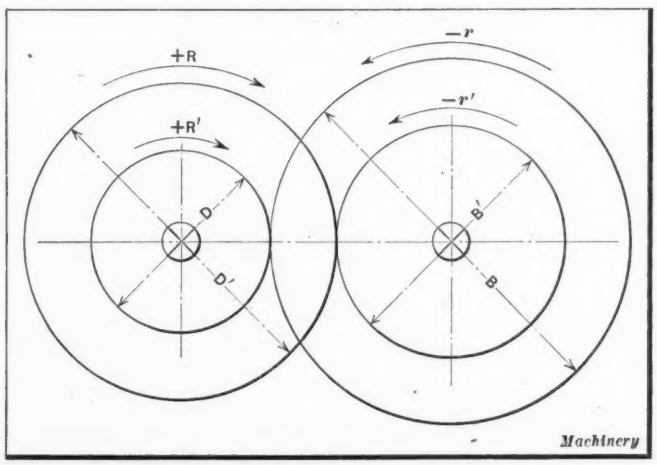


Fig. 8. Compound Gears in Fixed Bearings

Simple Internal Epicyclic Trains with Intermediate Gear

The interposition of an intermediate gear between a central gear and the internal gear, as shown in Figs. 5 and 6, forming the familiar "sun-and-planet" gear, is an arrangement that is frequently encountered and that well exemplifies the principles of epicyclic gear trains. In such arrangement, either the central gear or the embracing internal gear may be dead, but one must be stationary.

Considering the central gear as dead and the arm as driving, as shown in Fig. 5, the internal driven gear, if fixed so that it will have to revolve with and at the same speed as the driving arm, will make a revolution for each rotation of the arm and in the same direction. With the arm fixed, the rotary motion imparted to the internal gear during a revolution around the central gear is the same as that imparted to it by a revolution of the central gear in the same direction. The planetary idler reverses the direction of rotation and the rotary motion will be measured by that part of a complete revolution represented by the quotient of the diameter of the central gear divided by the diameter of the internal gear. The speed of the driven internal gear, the central gear being dead, is then equal to the speed of the driving arm multiplied by one plus the quotient of the diameter of the dead gear divided by that of the embracing internal gear.

By making the internal gear the driving member, instead of the arm, as shown in Fig. 6, the co-relationship of the rotary speeds of the effective members is quite different. Considered as fixed, that is, turning with and at the same speed as the internal gear, the arm will make a revolution for each revolution of the internal gear and in the same direction. Considering the internal gear, or the driving member, as fixed, the retarding influence of the rotating planetary idler can be ascertained from the reverse rotation of the central gear, which will produce the same effect upon the planetary idler as a forward revolution of the internal gear. The number of reverse turns of the central gear required for such result will be equal to the quotient of the diameter of the internal gear divided by that of the central gear. For each of these reverse revolutions of the central gear, the arm will be turned in the same direction for that part of a revolution measured by the reciprocal of the number of reverse turns of the central gear required

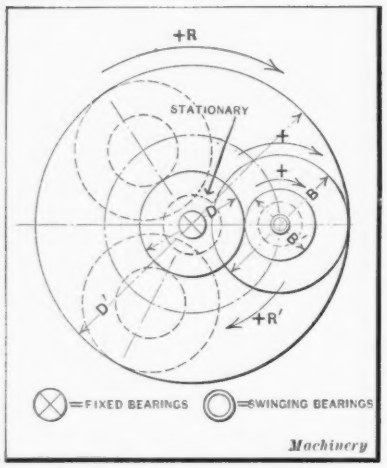


Fig. 11. Compound Internal Epicyclic Train

to actuate the planetary idler in the same manner as a forward revolution of the internal gear. This portion of an arm revolution will also be measured by the ratio of the rotary speed of the central gear to that of the internal gear, when the driving arm is fixed, so the retarding influence of the planetary idler is equal to this speed ratio multiplied by the portion of a reverse revolution of the arm made during a reverse revolution of the central gear. Simplified, the retarding influence of the planetary idler is equal to the rotary speed of the driven arm multiplied by the quotient of the diameter of the central gear divided by that of the internal gear. The rotary speed of the driving internal gear minus this measure of the retarding influence of the planetary idler is then equal to the speed of the driven member of the mechanism, the arm.

The sun-and-planet gear may also be arranged so that the driving member is the central gear and the internal gear the dead member. In such construction, the retarding influence of the planetary idler, per revolution of the arm, will be measured, not by the quotient of the diameter of the central gear divided by that of the internal gear, but by the quotient of the diameter of the internal gear divided by the diameter of the central gear. This gives a speed formula similar in form to that for the arrangement shown in Fig. 6, but with the diameter of the central gear substituted for that of the internal gear and that of the internal gear for that of the central gear.

If both the central and internal gears are free to revolve in any of the sun-and-planet gear arrangements, the effective members will revolve at the same speed. The intermediate gear, the planetary idler, will lock the effective members in relation to one another. The planetary idler, or idlers should there be a number of them as in most adaptations of this type of speed reducer, in rolling around the internal gear will tend to cause the central gear to revolve in the opposite direction, and in rolling about the central gear to cause the direction of rotation of the internal gear to be reversed, so that the whole mechanism will have to revolve as a unit about the central shaft.

Compound Gear Combinations

The foregoing arrangements cover all types of simple epicyclic gear trains; the more complicated arrangements involve the use of compound gear combinations. The arrangement of gears shown in Fig. 8 illustrates the principles of compound gearing in fixed bearings. More gears may be placed on the respective shafts in order to secure a greater speed ratio for the train, or there may be more than two shafts, as shown in Fig. 9, upon at least one of which a compound gear must be mounted without in any way affecting the general principle and the compound gear rule, which is: The ratio of the velocity of the driven gear to that of the driving gear is equal to the ratio between the continued product of the diameters of the driving gears to the continued product of the diameters of the driven gears. In a train with an odd number of compound gears, the direction of rotation of the effective driving and driven gears is the same, while if the number of compound gears is even, the directions of rotation are opposite; provided, of course, that other reversals in direction of rotation are not made by supplementary idlers.

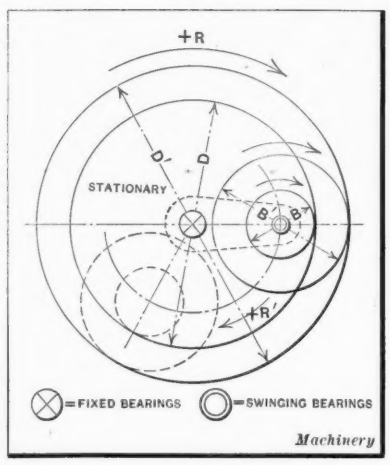


Fig. 12. Compound Double Internal Epicyclic Train

Compound Epicyclic Gear Trains

The arrangement of a compound gear on the swinging shaft meshing with simple dead and driven gears mounted on fixed bearings shown in Fig. 10 is the simplest variety of compound epicyclic train. The derivation of its speed formula will be given in detail. The dead gear, about the axis of which the driving arm revolves, is shown mounted on the same shaft as that carrying the driven gear in order that the rotation of the effective members may be concentric, which is the more practical arrangement, though not essential to the epicyclic principle; it is assumed that the pitch of all gears is the same. First, consider the driven gear fixed in the arm and the arm free to revolve, disregarding the meshing of the stationary gear with its mating gear. Under such conditions, the driven gear would revolve with the driving arm, making the same number of revolutions and in the same direction. Next, consider the driving arm fixed and the driven gear free to revolve. The motion (rotary) that will be imparted to the driven gear by a revolution of the driving arm is the same as will be imparted to it, with the driving arm fixed, by a revolution of the central gear in the reverse direction. Reversing the rotation of the central gear will also reverse the direction of rotation of the driven gear. As both the central gear and the driven one are mounted on the same shaft, the motion imparted to the driven gear by its rotation on its own axis through the agency of the compound gear on the swinging shaft is negative. This motion, considering the central gear as a driver, is equal to the product of the diameters of the driving gears by the speed of the driving arm divided by the product of the diameters of the driven gears. The speed of the driven gear is then equal to the sum of the positive motion due to its revolution with the driving arm and of the negative motion due to the agency of the compound gear, or is equal to the speed of the driving arm multiplied by one minus the quotient of the product of the diameters of the driving gears by the product of the diameters of the driven gears.

If the product of the diameters of the driving gears is less than that of the driven gears, as shown in Fig. 10, the direction of rotation for both the driving arm and the driven gear will be the same. If the products of the diameters are equal, the driven gear will not revolve, no matter what the speed of the driving arm may be. While should the product of the diameters of driving gears be greater than that of the driven gears, the driving arm and the driven gear will revolve in opposite directions.

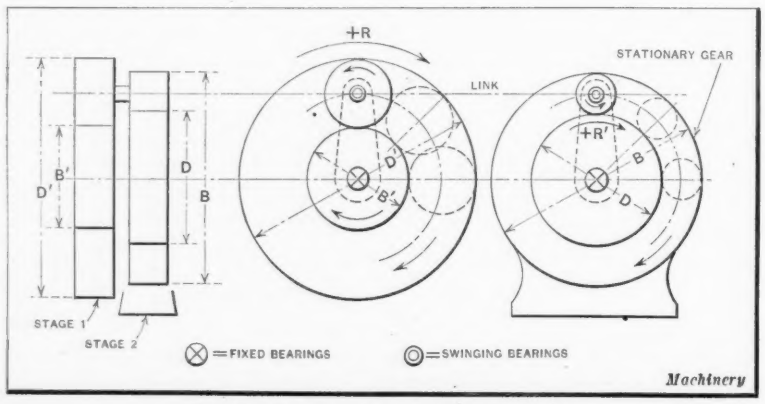


Fig. 13. Two-stage Internal Epicyclic Train

Compound Internal Epicyclic Trains

The substitution of an internal gear for the externally meshing driven gear of the preceding arrangement, as shown in Fig. 11, simply reverses the direction of motion imparted to the driven

gear through the agency of the compound gear so that the rotary speed of the driven gear is equal to that of the driving arm multiplied by one plus the quotient of the product of the diameters of the driving gears divided by the product of the diameters of the driven gears. The direction of rotation of the driving arm is necessarily the same as that of the driven gear, for no reverse motions or retarding influences occur in this arrangement of epicyclic gearing. Making either the internal gear or the central gear the driving member and the arm the driven member of the combination alters the co-relationship of the speeds of the effective members in a manner analogous to the changes in the speed formulas for sun-and-planet gears when the arm is changed from the driving to the driven member in such gear combinations.

Still another modification of the simple compound epicyclic train is shown in Fig. 12, in which both the dead gear and the driven gear are of the internal type. With this arrangement of gearing, the rotary speed of the driving arm bears the same relationship to that of the driven gear as in the arrangement of a compound train of externally meshing gears. The motion of the driven gear, by virtue of its rotation with the driving arm, is positive, while the motion imparted to it through the agency of the compound idler is negative. When the diameter of the dead gear is less than that of the driven gear, in this variety of compound epicyclic train, the diameter of the section of the compound idler rolling with the stationary gear is also less than that of the section driving the driven internal gear. As a result, the product of the diameters of the driving gears is less than the product of the diameters of the driven gear and the driven gear revolves in the same direction as the driving arm. If the two internal gears are of the same size, unless of different pitch, there will be no motion of the driven gear; while if the dead gear is the larger of the internal gears and of the same pitch as the other, the direction of rotation of the driven gear will be opposite to that of the driving arm.

A modification of this general arrangement with two internal gears, whereby either of the internal gears becomes the driving member and the arm the driven member, affects the speed ratio of the combination in much the same way as converting the arm from a driving to a driven member in compound epicyclic trains with only one internal gear. The difference is that in the case of trains with two internal gears the influence of the compound idler is positive instead of negative.

Compound Epicyclic Trains with Gears of Different Pitch

The pitch of the gears is specified in the foregoing arrangements of compound epicyclic gear trains, as the compound gears in such mechanisms may have sections of different pitch, thereby securing speed ratios that could not be practically obtained in any other way. A change of pitch affects the speed ratio in the same manner as a variation in the diameter of the gears. In such instances, therefore, it is necessary to substitute the number of teeth in the gears for their diameters in the speed formulas. The examples of simple and compound epicyclic gear trains that have been considered cover the general types of epicyclic gearing, but these simple mechanisms may be still further compounded by additional gearing; simple epicyclic trains may be combined with compound epicyclic trains, etc., so that a great number of different epicyclic gear mechanisms can be evolved. They will all be based on the same general principles as those that have been described, however, and a clear conception of their action requires but an analytical study of the individual motions involved and the application of the general formulas that have been derived, which are listed in the accompanying table.

Notation for Formulas

Diameter, number of teeth, of dead gear..... D
Diameter, number of teeth, of driven gear..... D'
Diameter, number of teeth, of section of compound gear meshing with dead gear..... B
Diameter, number of teeth, of section of compound gear meshing with driven gear..... B'
Velocity, revolutions, of driven gear, or arm..... R
Velocity, revolutions, of driving gear, or arm..... R'

Two-stage, Internal Epicyclic Gear Reducer

An example of a more complex epicyclic gear train—a successful speed reducer—is shown in Fig. 13. This mechanism is made up of two stages, each of which is composed of a central gear, about which there is a comparatively large concentric internal gear, one slightly larger than the other but both of the same pitch, and between the central gears and their respective circumscribing internal gears is a compound plane-

GENERAL SPEED FORMULAS FOR EPICYCLIC GEAR TRAINS

Type of Train	Number of Gears	Formulas	Rotation R and R'	Form. No.
Simple.....	2	$R = R'\left(1+\frac{D}{D'}\right)$ $R' = \frac{RD'}{D'+D}$	Same	(1)
Simple, with idler and arm driving	3	$R = R'\left(1-\frac{D}{D'}\right)$ $R' = \frac{RD'}{D'-D}$	Same or opposite	(2)
Simple internal, with arm driving and pinion dead	2—1 internal	Same as Formula (2)	Same	....
Simple internal, with arm driving and no dead gears		Same as Formula (2)	Same	....
Simple internal, with idler and arm driving.....		Formula (1)	Same	....
Simple internal, with idler and internal gear driving, central gear being dead.....	3	$R = \frac{R'D'}{D'+D}$ $R' = R\left(1+\frac{D}{D'}\right)$	Same	(3)
Simple internal, with idler and central gear driving, internal gear being dead.....		$R = \frac{R'D}{D+D'}$ $R' = R\left(1+\frac{D'}{D}\right)$	Same	(4)
Compound.....	4	$R = R'\left(1-\frac{DB'}{D'B}\right)$ $R' = \frac{RD'B}{D'B-DB'}$	Same or opposite	(5)
Compound internal, with arm driving	4—1 internal	$R = R'\left(1+\frac{DB'}{D'B}\right)$ $R' = \frac{RD'B}{D'B+DB'}$	Same	(6)
Compound internal, with internal gear driving and central gear dead	4—1 internal	$R = \frac{R'D'B}{D'B+DB'}$ $R' = R\left(1+\frac{D'B}{DB'}\right)$	Same	(7)
Compound internal, with central gear driving, internal gear being dead		$R = \frac{R'DB'}{DB'+D'B}$ $R' = R\left(1+\frac{DB'}{D'B}\right)$	Same	(8)
Compound internal, having two internal gears with arm driving		Same as Formula (5)		
Compound internal, having two internal gears, the larger internal gear driving.	4—2 internal	$R = \frac{R'D'B}{D'B-DB'}$ $R' = R\left(1-\frac{DB'}{D'B}\right)$	Same or opposite	(9)
Compound internal, having two internal gears, the smaller internal gear driving.....		$R = \frac{R'DB'}{DB'-D'B}$ $R' = R\left(1-\frac{D'B}{DB'}\right)$	Same	(10)

Machinery

tary idler. The internal gear of one of the stages is stationary, a dead gear, and encircles the driving gear of the combination, the arm being the driven member. The internal gear of the second stage is the driven member of the combination, while the central gear it circumscribes is active and rotates with and in the same direction as the driving gear of the first stage.

Stage 1 is obviously a simple internal epicyclic train in which the central gear is the driving member, the arm the driven member, and the internal gear the stationary, or dead, member. One revolution of the driving gear will cause the driven arm to make but a partial revolution, measured by the quotient of the diameter of the driving arm divided by the sum of the diameters of the driving gear and the stationary internal gear, according to Formula (4) in the table.

Stage 2 is also a simple internal epicyclic train but of a somewhat special nature, as there is no dead member. This adds a third motion to this stage, which affects the speed of the driven gear but is quite independent of the action of Stage 1; that is, the third motion is not apparent in Stage 1 but must be considered in Stage 2. Without this third motion, the speed of the driven gear, the arm of Stage 2 being the driving member for the second simple internal train, would be equal to the speed of the driving member multiplied by one plus the quotient of the diameter of the central gear divided by that of the internal gear, Formula (1), the direction of

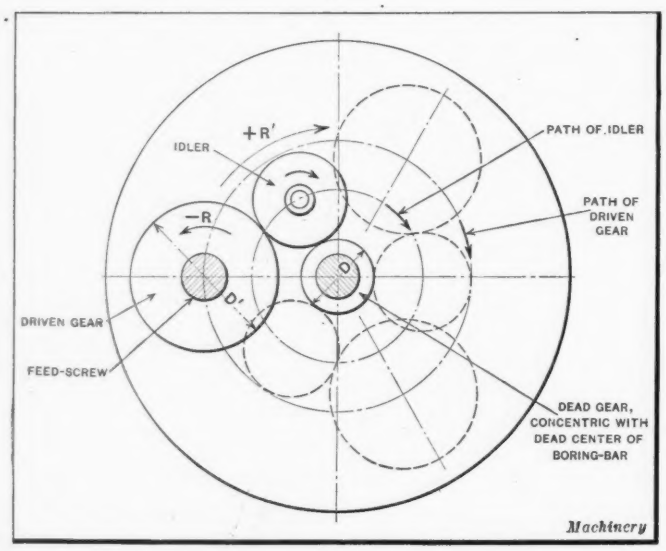


Fig. 14. Epicyclic Gear Train in Boring-bar

rotation being the same as that of the driving arm and of the driving gear in Stage 1. As the speed of the driving arm for Stage 2 is the same as the speed of the driven member of Stage 1, the speed of the driven gear of the combination, disregarding the third motion produced by the live central gear of Stage 2, would be equal to the product of the speed developed in Stage 2, in terms of the speed of the rotating arm, and the ratio of the speed of the driven arm to that of the driving gear of Stage 1. This speed ratio is equal to the diameter of the driving gear divided by the sum of the diameters of the driving and stationary gears. The third motion affecting the speed of the driven gear, that due to the revolution of the central gear in Stage 2, is a negative one, the central gear and the driven gear revolving in the same direction and the motion being transmitted between them through the agency of an intermediate gear. This retarding motion is measured, per revolution of the driving member of the combination, by the quotient of the diameter of the central gear (Stage 2) divided by that of the driven gear, so that the net speed of the driven gear is measured by the speed it would have had but for this retarding motion minus the reduction in speed due to the activity of the central gear. Expressed in algebraic form, the relationships between the driving and driven speeds of the mechanism are:

$$R = \frac{R'\,(DD' - B'\,B)}{D'\,(D + B)} \text{ and } R' = \frac{RD'\,(D + B)}{DD' - B'\,B}$$

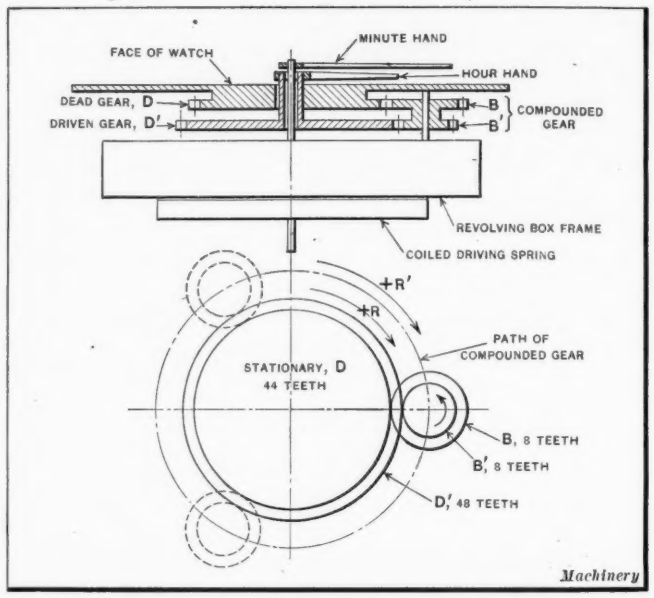


Fig. 15. Compound Epicyclic Train in Waterbury Watch

Obviously this two-stage, internal, epicyclic gear train speed reducer can be proportioned to develop a high speed ratio. Such a mechanism, having the stationary gear 24 inches in diameter, driven gear 24.2 inches, the driving gear 20 inches, and the central gear of the second stage 19.8 inches in diameter would have a speed ratio of 121 to 1. In this case the driving gear D is 20 inches, the driven gear D' is 24.2 inches, the stationary gear B is 24 inches, and the central gear B' is 19.8 inches diameter. Therefore, the speed of the driven gear, in terms of the speed of the driving gear is:

$$R = \frac{R'\,(20 \times 24.2 - 19.8 \times 24)}{24.2\,(20 + 24)} = \frac{8.8\,R'}{1064.8} = 0.0082644\,R'$$

The speed ratio is, therefore, $R' : R = 121 : 1$.

Epicyclic Gear Trains in Boring-Bars

Certain types of boring-bars use a simple epicyclic train by which the revolution of the bar on its dead center is employed to carry the feed-screw (within the bar) about a circular path concentric with the dead center of the tool, and in so doing impart the rotary motion to the screw required for the feed. For this construction a sliding type of head is essential, the driven gear of the epicyclic train being attached to the end of the feed-screw, as indicated in Fig. 14.

The epicyclic train is of the simple type with an idler, the function of the latter gear being to secure opposite directions of rotation for the boring-bar and the feed-screw. This necessitates making the driven gear of the train larger than the dead gear. In Fig. 14, the driven member is the gear at the end of the feed-screw, the driving member is the arm measured by the offset of the feed-screw from the dead center of the boring-bar, and the stationary gear is a dead gear concentric with the dead center of the boring-bar. Assigning a diameter of 5 inches to the dead gear and one of 10 inches to the driven gear at the end of the feed-screw, the boring-bar will make one revolution while the feed-screw makes but one-half

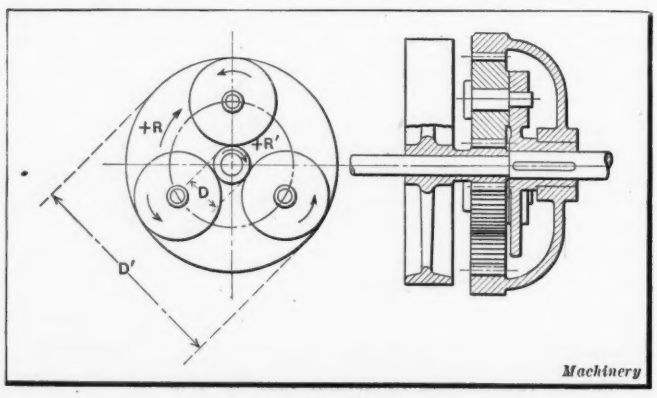


Fig. 16. Differential Back-gear

a revolution. This is shown by substituting in Formula (2) $D = 5$ inches, $D' = 10$ inches, $R' = 1$. With a feed-screw of 8 threads per inch, this would give a boring-bar feed of 1/16 inch per revolution.

Compound Epicyclic Gear Trains in Watches

One of the commonest examples of a compound epicyclic gear train is to be found in the mechanism that actuates the hands of certain watches; and this is one of particular interest, as the desired speed ratio is best secured by slightly altering the pitch of the compound gear. The change of pitch makes it possible for the double gear of individual gears to have the same number of teeth, as the two sections differ but slightly in diameter, and thus secure the same result as if the compound gear were made up of individual gears of the same pitch but a different number of teeth and the corresponding difference in diameter.

Fig. 15 illustrates diagrammatically the mechanism used in the Waterbury watch on a somewhat distorted scale in order to more clearly depict the construction. The minute hand is carried on the end of a shaft upon which is mounted a revolving box frame containing other mechanism essential to the operation of the watch but that does not constitute any part of the epicyclic gear train. This frame, which acts as the driving arm of the epicyclic train, is rotated by a coiled spring at the rate of one revolution per hour. Protruding from the box frame, near its circumference, is the shaft carrying the compound gear. One section of this compound gear engages a dead gear fastened to the face of the watch, and the other section meshes with a gear attached to the sleeve carrying the hour hand. This latter gear, which is the driven gear of the train, the dead gear, and the path of the compound pinion as it is carried by the box frame are all concentric, and the train is evidently of the simple compound type for which Formula (5) is applicable.

In the Waterbury watch, the compound gear is made up of what is equivalent to two individual gears of eight teeth each, but slightly differing pitch; the dead gear has forty-four teeth and the driven gear actuating the hour hand has forty-eight teeth. Substituting the number of teeth in the various gears for their respective diameters in Formula (5) the speed of the driven gear is found to be one-twelfth that of the driving member, or the revolving box frame. That is, the hour hand makes one-twelfth revolution while the minute hand circles the watch.

Differential Back-gearing

An example of the application of epicyclic gear trains to machine tools, which is probably their most familiar use, is the back-gearing of drilling machines and other light machine tools. Such a mechanism is shown in Fig. 16 and is of the sun-and-planet gear type for which the speed formula is that given as Formula (4). The driving member is the central gear and the large internal gear is stationary while the reducer is in operation. A differential gear in which the embracing internal gear is 18 inches in diameter and the central gear 3 inches will have a speed ratio of 7 to 1, according to Formula (4), where $D = 3$ and $D' = 18$ inches, the direction of rotation of the connecting shafts being the same. By locking the mechanism and liberating the internal gear, the two abutting shafts will revolve at the same speed and, of course, in the same direction.

* * *

The general experience is that severe vibration tends to tire workmen and make them irritable and inefficient. In one case where vibration occurred, a correspondent states that it was necessary for the company to take prompt measures to overcome it, as under certain conditions it was impossible for the employes to stand it for a very long time. This meant that if they had to work on a floor which was vibrating, they were far from 100 per cent efficient. In the case of women it seemed impossible for them to stand the vibration even temporarily on account of the nervous strain. It is believed that employes working under such conditions as were there present were not over two-thirds efficient.—*Extract from "The Effects of Vibration in Structures," published by the Aberthaw Construction Co., Boston, Mass.*

SLIPPAGE OF BELTS RUNNING AT HIGH SPEED

BY W. A. LAILER

One of the troubles encountered in belt-transmission practice, especially where the belts are run at high speed, is the slipping of the belt on the driven pulley, making it almost impossible to maintain proper speed ratios between the driver and the driven pulleys. The lost motion caused by the slipping of the belt results in the driven pulley being operated at a speed below that figured for it from the formulas or equations used for obtaining pulley speeds; and where the efficient operation of a machine is dependent on its running at the proper rate of speed, the uncertainty introduced is a serious matter. What makes the problem even more difficult is the fact that this slippage does not follow any fixed ratio or proportion, but varies for each particular set of conditions, and may even vary at different times under the same general operating conditions, because of weather, etc.

In general, two theories are advanced as to the cause of belt slippage: First, that it is due to an air cushion being drawn between the belt and the pulley; and second, that it is due to centrifugal action. The first theory is based on the assumption that the high speed of the belt causes air to be drawn in under it as it approaches the pulley, forming an incompressible air cushion between the belt and pulley surface on which the belt skims and slides instead of actually coming in contact with the tractive face of the pulley. Following the conclusions reached by this line of reasoning a number of methods have been devised for eliminating these so-called air-cushions between the belt surface and the pulley face. Probably the simplest method is the use of a pulley with holes in it to allow the immediate release of any air entrapped between the belt and the pulley. Another method is to place a small deflector near the under surface of the belt, just before it enters the pulley, so that any air pockets carried with the belt will be broken up and dispelled. This deflector may be made stationary where the belt passage is constant; or where vibrations are present, it may be held lightly against the inner surface of the belt by means of a light spring bracket. Still another method is to cut grooves in the surface of the pulley so that the air is forced into the grooves while contact is established between the elevated parts of the pulley face and the belt.

The theory of air cushioning is discounted by many on the ground that the tension pressure between the belt and pulley is so great as to make impossible the retaining of any film of air. Those who belittle the theory of air cushioning usually claim that the slippage in high-speed belts is due to centrifugal force, which causes the belt to stretch and tends to make it rise off the pulley face. It is admitted that the belt does come in contact with the pulley at frequent enough intervals to supply tractive power, but it is also momentarily thrown off the pulley face, thus making it appear as if it were riding on the air cushion. In support of this theory, it is pointed out that the lower the belt speed the lower will be the centrifugal force, and hence the less the belt will stretch. It has been found that with belts running up to 4500 or 4800 feet per minute no trouble from excessive slippage due to centrifugal action is encountered, but at higher speeds the force brought into play due to centrifugal action is sufficient to cause a considerable falling off in efficiency.

Another check of the correctness of this theory is the fact that the slipping of the belt can be eliminated by taking up any stretching due to centrifugal force that may occur after the pulley gets up to speed by drawing the pulley out to the belt, through the use of adjusting screws and sliding frames. It will be noted that when the belt is stopped and the centrifugal tension released, the driven pulley must be drawn back again to its former position, or the belt will span tightly between the two pulleys and will be subjected to great internal strain. This theory can be tested by mounting the driven pulley on a sliding frame with adjustable screws, as is the general practice in motor construction. Then after the belt is started, the stretch caused by centrifugal force may be taken up by adjusting the screws and drawing the pulley out

against the belt in its stretched position; but the operation must be reversed before the belt is stopped and centrifugal tension is released. Another remedy for this trouble would be to use a belt made of some material that will not stretch. Unfortunately no material that is strong and pliable enough to do the work has been found that will not also be subjected to this stretching action.

* * *

CHANGES IN MANUFACTURE

BY ERIC LEE[1]

It is interesting to note how both small and large results may be obtained from a change in manufacture. When the original lay-out was made, something may have been overlooked, and often one operation may be substituted for two or more others. But sometimes it is cheaper not to interfere with the original lay-out, as the changing over or making of new machines, jigs or fixtures will exceed the profit obtained.

When a new product is to be made, the operations are considered separately and collectively. All the apparatus for each operation is taken into account, the foremen of the shops are consulted, their opinions upon the routine of operations noted, and prices fixed before any permanent method of manufacture is adopted. But in all mechanical industries, whatever standard has been adopted, the only visible constant is change. However good a lay-out may be, it is only relative, and from time to time it has to be made flexible by a change in manufacture. Many factors must be taken into consideration, however, and a large profit must be shown before any radical change is made. Among the things to be considered are the amount of the product on the market and in the storehouses, the number likely to be returned for repair, and the interchangeability of the new part with parts formerly made; that is, it must be determined whether the parts changed in manufacture can be altered so as not to be noticeable in an article that has obtained a wide reputation, and whether the change will materially affect any other part of the mechanism. Changes of tools, gages, jigs and fixtures must also be carefully considered.

If the original lay-out was properly performed and each operation considered separately and collectively, it will be difficult, through a slight change in design, to bring about a new and proper sequence of operations. While a temporary change may prevent a lot going to the scrap pile through being milled small or splined too large, or for some similar reason, it is sometimes better to locate the origin of the defect, scrap the lot, and use such measures as will eliminate the cause. In large manufacturing concerns, when a change is necessary and the resulting profit is likely to be considerable, some plan should be devised whereby the manufacture of the gages, jigs, fixtures and machines used for the operation that is to be discarded will be automatically stopped until the necessary changes have been made upon the blueprints by some drafting-room official; and as these mechanical devices are made in various shops, it is essential that this plan works properly.

A change in manufacture does not always eliminate an operation; sometimes it may add one. There have been cases where two operations cost less than one. In one instance, where drilling and counterboring were done at a cost of 22 cents per hundred, by dividing this work into two operations and paying 10 cents a hundred for drilling and 8 cents a hundred for counterboring, a saving of 4 cents a hundred was accomplished. This gain was brought about by speeding up the drilling and letting the counterboring run at a more moderate speed. The workmen made just as much pay, but the cost of cutting tools was greatly diminished, as it was expensive to make the counterbore and drill in one piece, and when it broke both the drill and the counterbore had to be scrapped. When the drill and counterbore were made separately, they cost less and could be ground more easily; the work was also done more quickly, as several drills and counterbores were kept on hand.

It has been found expedient to make a change in a ring gage, when a lot of 10,000 has run small. However, with up-to-date methods of gaging it seems almost impossible to run over 500 parts small. Sometimes, when gages suffer excessive wear, as, for instance, thread gages, all gages are called in on Saturday, inspected on Sunday, and are ready for work the next day; this plan, however, is expensive, as it entails much overtime for gage-makers. Another method is to provide two sets of gages. One set is in the gage-room while the other is in the shop, and the sets are changed every week, so that those in use are continually being inspected.

Sometimes when a change of manufacture is necessary, the designer will visit the store-room and redesign some discarded machine at low cost. At other times, a designer will try to change over a machine that is quite inadequate for the operation necessary. In many cases, a new machine could have been built for one-half the cost required to change over an old one, just to prevent its being an eyesore to the master mechanic.

Often changes are suggested that a little consideration would prove inadvisable. A design was once made over for a slight change in manufacture, and a fixture costing $275 was built to take the place of a templet for laying out work. This templet was made from a piece of stiff brown paper, and when one piece of paper was worn out another was substituted. However, it was thought that by the aid of this new fixture women could be employed to do the work, which was extremely light. A trial showed that the new fixture quickly lost its shape, so it was found cheaper to discard it and go back to the old method.

[1]Address: 195 Bassett St., New Haven, Conn.

* * *

RESOLUTIONS ADOPTED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The American Society of Mechanical Engineers adopted three important resolutions at the Cincinnati meeting relating to war conditions, as follows:

Dissemination of Munitions Standards

Whereas, serious delays have been experienced in other countries and this country in the production of munitions work, and rejection and unnecessary loss to manufacturers, and its consequent shortage of labor and material due to lack of control of data and of standards of measurement; and

Whereas, Great Britain, Canada and France have found standardization of measurement of all war material for both army and navy imperatively necessary to obtain uniform and reliable results, and have constructed an efficient organization, which has proved successful in overcoming these difficulties; and

Whereas, increased efficiency of our manufacturers would be promoted by the establishment of proper standards of measurement; be it

Resolved, that the Congress be urged to appropriate sufficient funds for expenditure through the Munitions Board, or other agency, to provide standards and adequate means of calibration, distribution and supervision of such standards, including means for calibration of working and inspection standards in the different centers of munitions manufacture.

Also that provision be made in this appropriation for the establishment of a central office for the collection and dissemination of information on the methods of manufacturing munitions and other supplies.

Resolved, that the American Society of Mechanical Engineers indorse any effort tending to promote the ends outlined above, and in view of the imperative needs of the present situation, most strongly urge immediate action.

No Secrets in Munitions Work

Whereas, it is the patriotic duty of every manufacturer to facilitate and expedite the manufacture of munitions and other supplies for the army and navy; be it

Resolved, that an appeal be addressed to all manufacturers and engineers to cooperate in the dissemination of information and the interchange of data pertaining to methods of manufacture, system of organization, design of tools, operation of lay-outs and time studies, including what is generally known under the term "shop secrets," so far as they pertain to munitions manufacture.

Recognition of Munitions Workers

Whereas, it is necessary to obtain the patriotic cooperation of every man who can contribute to the furnishing of naval and military supplies; be it

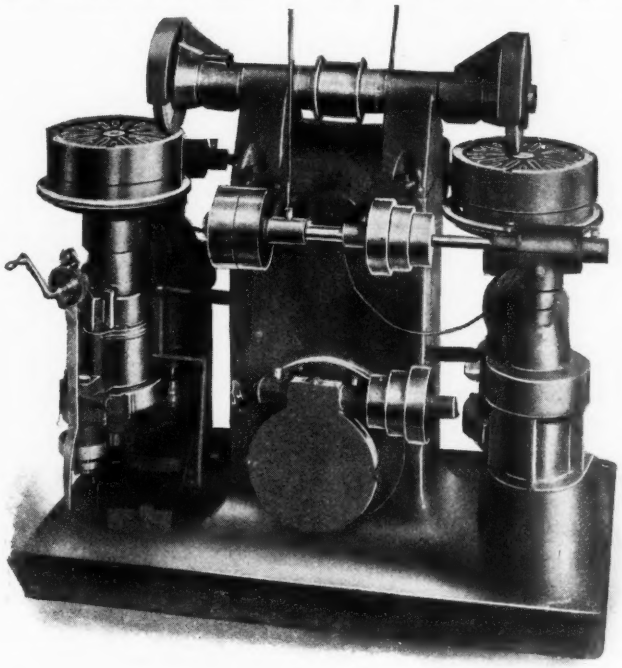
Resolved, that the American Society of Mechanical Engineers urge upon the government the necessity of indicating in some way the value and loyalty of men in service in industries whose occupation is essential to the production of war supplies.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

GLOBE ROTARY SURFACE GRINDER

The accompanying illustration shows a rotary surface grinder built by the Globe Machine & Stamping Co., Cleveland, Ohio, which is claimed to have the productive capacity



Duplex Rotary Surface Grinder built by Globe Machine & Stamping Co.

of two standard grinders, although requiring less attention from the operator. This grinder is really a double machine, so constructed that the mechanism of one chuck and grinding wheel can be operated as a unit entirely independently of the other. This feature permits the operator to prepare his work on the idle chuck and allows the grinding to continue without interruption. Both chucks can be operated simultaneously if so desired, thus enabling the operator to devote his attention to other work. The grinding wheel head is secured to the frame in a fixed position, affording a rigid construction and preventing the wheels from being thrown out of alignment.

There are no sliding surfaces on this machine, and all working parts are effectively protected from dust and abrasive grit. An automatic feed and stop is provided on the grinder, and by means of this device work can be fed to the grinding wheel from 0.0005 to 0.005 inch for each stroke of the machine. The stop can be set to release the feed at any point, and this relieves the operator from the necessity of concentrating his attention solely upon the grinding operation. Each operating unit is independently controlled, and all speeds, feeds, etc., have separate drives, thus making the grinder practically a double machine. Two 12-inch magnetic chucks are mounted on counterbalanced swinging arms with ball thrust bearings of large diameter. The swinging movement is caused by means of a cam and rocker arm of uniform motion, with means for adjusting the length and position of the stroke. There are three speeds for the revolving chucks and three for the work traverse. Six 3¾-inch piston rings can be ground simultaneously on each chuck, and the chucks can be set to grind either concave or convex work.

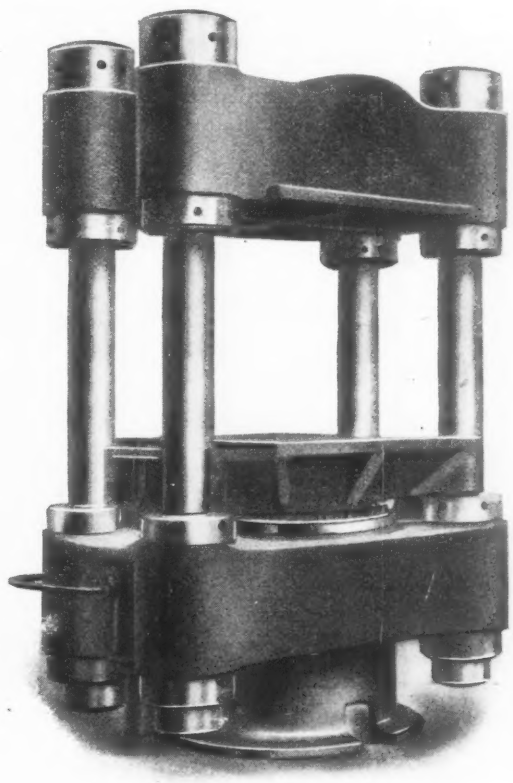
HYDRAULIC FORMING PRESS

Hydraulic pressure is being utilized more and more in forming various articles from sheet steel, steel plates, etc., because of its accurate and positive force. The press here shown was designed and built for steel plate and sheet forming operations. It has a pressure capacity of 1000 tons. The press has an unusually sturdy construction throughout, and is capable of performing heavy forming operations.

This press has an adjustable daylight space of 18 to 36 inches. To provide for this adjustable daylight, the upper ends of the strain-rods are threaded, thus permitting the maximum and minimum daylight to be obtained. The upper ends of the strain-rods are fitted with threaded forged nuts, while the lower ends are made with solid heads and split collars. Both the upper and lower strain-rod collars are threaded, the upper collars serving two purposes: first, to permit the head to be lowered, and, second, to take up all clearance so that the head can be set perfectly true for close work. The lower collars are threaded so that all clearance may be taken up.

The press is equipped with two auxiliary push-cylinders, the purpose of which is to hasten the return of the press platen and ram after the pressing operation. These push-cylinders are equipped with differential rams, the upper ends of which are smaller than the lower. This provides a shoulder on the rams in the cylinders and forms an area to take the water pressure for forcing the ram.

This press may be operated from either an independent pump or an accumulator system. The accumulator is the most satisfactory arrangement, especially where there are several presses being operated, as when the valves of all the presses are opened at one time, an unusual load occurs and the pumps are unable to care for it. The pressure may be allowed to remain on the auxiliary cylinders or they may be operated by means of double-acting operating valves. This press is of steel construction throughout, a large factor of safety being allowed in its design for the heavy pressure which it exerts. It has a pressing surface of 42 inches by 48 inches. This equipment is built by the Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio.



Forming Press of 1000 Tons Capacity built by Hydraulic Press Mfg. Co.

ELGIN AUTOMATIC CHUCK CLOSER

The Elgin Tool Works, Elgin, Ill., are now making an automatic chuck closing attachment to fit any of their bench lathe heads. These attachments may be put on or taken off quickly; they are of simple construction, work easily and rapidly, and are convenient where duplicate chucking operations are being performed. With one of these attachments the lathe does not have to be stopped for loosening or tightening the collet.

The Elgin automatic chuck closer consists of a draw-spindle, two sleeves, dogs, yoke and bracket. The draw-spindle is

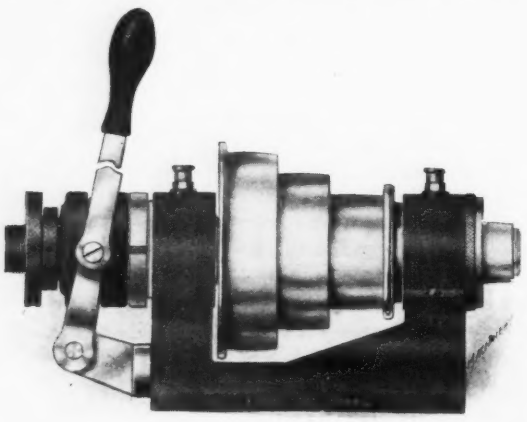


Fig. 1. Automatic Chuck Closer for Bench Lathes made by Elgin Tool Works

threaded on the rear end and fitted with two check-nuts which adjust the tension on the collet. An inner sleeve slips directly over the lathe spindle and is held in place by a set-screw, the point of which fits into a hole provided on the spindles of all Elgin bench lathes. This sleeve also carries the dogs, which are operated by the sleeve and yoke that open and close the collet. The bracket is held in place on the head by means of two screws, tapped holes for which will be found on all Elgin lathe heads.

This automatic chuck closer is so designed that it requires no extra fitting, but may be placed on any head, making use of the tapped holes provided for the indexing, dividing and other attachments. The attachment does not interfere with the ordinary use of the draw-spindle. Used in conjunction with this company's double tool-slide rest, it will be found convenient for manufacturing small duplicate parts. Fig. 2 shows another new product of the Elgin Tool Works, which is known as a No. 4 by 5 bench lathe. In the February, 1909, number of MACHINERY a description was published of a No. 4

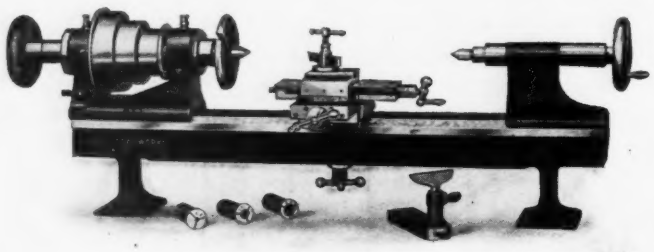


Fig. 2. No. 4 by 5 Bench Lathe built by Elgin Tool Works

bench lathe manufactured by this company, and the present machine is of similar design except that the parts subject to strain have been made considerably heavier to adapt the machine for more severe classes of service.

HARDY GRINDING ATTACHMENT

To provide for performing grinding operations on bench lathes, Charles Hardy, 1051 Boston Road, New York City, has developed a grinding attachment which is capable of handling both internal and external work. It will be seen that a graduated swivel is furnished for setting the attachment at the proper helix angle for thread grinding. The swivel is clamped in any desired position by means of a headless set-screw, which,

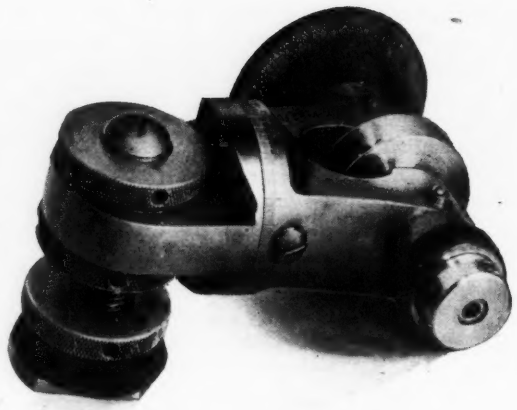


Fig. 1. Grinding Attachment for Bench Lathe built by Charles Hardy

in turn, operates a tapered half ring that is seated in an annular groove of corresponding taper. Application of pressure on the ring by this set-screw causes the latter to expand and bind firmly in the annular groove.

Vertical adjustment is also provided which enables the attachment to be raised or lowered according to requirements of different grinding operations. This vertical adjustment has a maximum range of one inch from the lowest to the highest position. The spindle has double tapered bearings of 5 and 50 degrees taper angle. Both spindle and bearings are hardened and ground, and the bearings are furnished with oil chambers to insure efficient lubrication. For internal grinding an extension spindle is used, which is furnished with a draw-

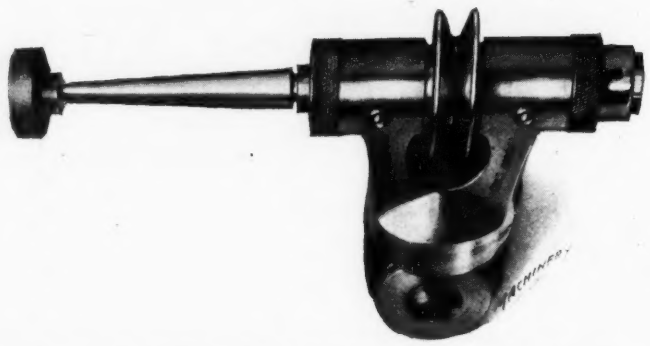


Fig. 2. Attachment shown in Fig. 1 equipped with Internal Grinding Spindle

back mechanism that holds it securely. The attachment may be driven at any required speed for the efficient operation of grinding wheels from ¼ inch to 3 inches in diameter.

In addition to its use as a grinding attachment, this tool may be employed for the operation of fine end-mills. For this class of work it is held in a vertical position by means of an arm, and the swivel is employed to obtain any required angular

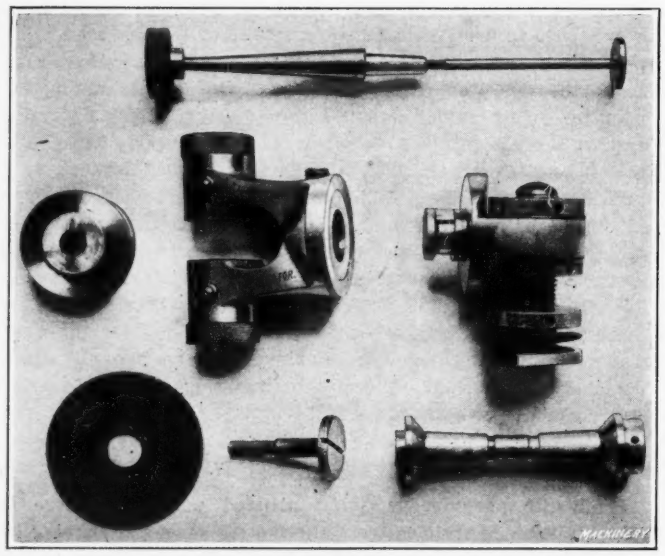


Fig. 3. Parts of Hardy Bench Lathe Grinding Attachment

setting. Used in this way, the tool will be found adaptable for many classes of work which may be conveniently done with small sized end-mills. A feature of the attachment is that it can be easily taken apart for cleaning or adjustment. This may be done in a few moments, and the only tools required are a small screwdriver and spanner wrench, which are included among the tools furnished with the attachment.

MAGNA TURRET TOOLPOST

The Magna Machine Co., 50 Church St., New York City, is now manufacturing the turret toolpost shown in the accompanying illustrations. This toolpost will fit any engine lathe, and one size is interchangeable between all lathes from 11 to 20 inches swing. An exceptionally large number of tools can be mounted in this toolpost, and they are always clear from the chuck and working material. The toolpost will finish a piece of work completely inside and outside, including threading and cutting-off operations. A sequence of operations can be performed at a single setting of the work and without the necessity of changing tools, so that considerable time will be saved where a number of operations must be performed.

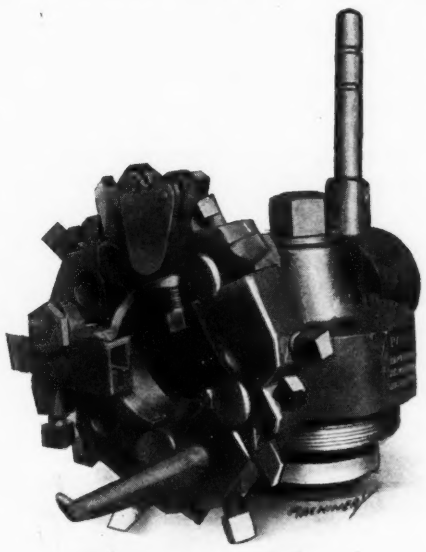


Fig. 1. Magna Turret Toolpost

This turret toolpost is equipped with a cutting-off blade in such a position that cutting off can be done close to the lathe chuck. All external cutting tools are independently adjusted, when necessary, by means of a set-screw. The toolpost is inserted in the tool slot of a compound rest, and a threaded sleeve provides a vertical adjustment of about ¾ inch to accommodate it for lathes of various swings. One set of tools is furnished as part of the equipment, consisting of a knurling tool, four ⅝-inch boring tools, four ⅜-inch square high-speed tool bits, and one ¾-inch high-speed cutting-off blade. The dimensions of the toolpost are 8½ inches long by 8 inches high by 6½ inches deep, and it weighs 18 pounds.

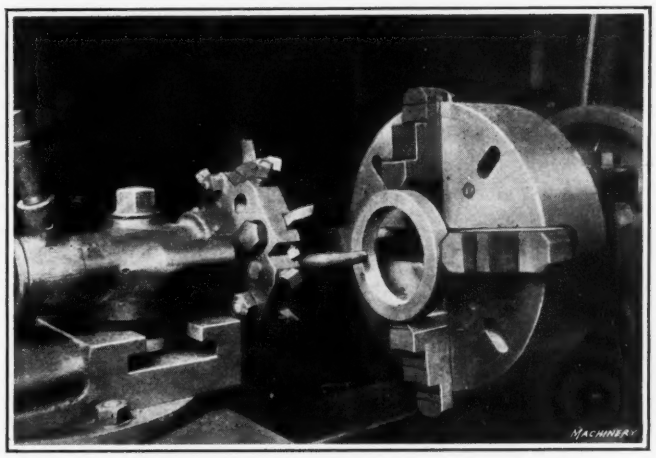


Fig. 2. Magna Turret Toolpost in Operation on Lathe

DETROIT PNEUMATIC CHUCKS

Figs. 1 and 2 show a milling fixture recently made by the Detroit Pneumatic Chuck Co., Flat Rock, Mich., to hold carbureter bodies. These bodies are first machined on turret lathes, in which they are held by air chucks while the first operations are performed. For milling, the fixture is strapped on the top of the milling machine table and is furnished with a two-jaw chuck with jaws made especially to fit the work. The cylinder is attached to a bracket at the opposite side of the chuck, making a compact construction. A valve is fastened on the end of the cylinder, with the supply pipe

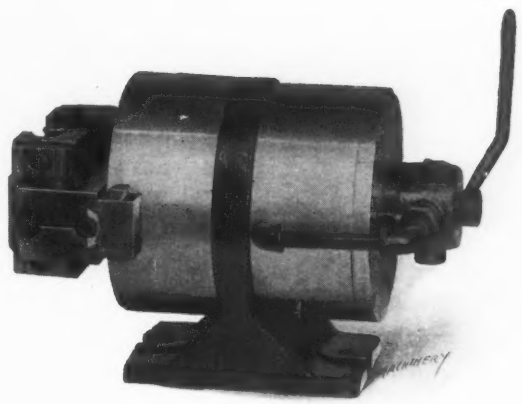


Fig. 1. Detroit Pneumatically Operated Milling Fixture for Carbureter Bodies

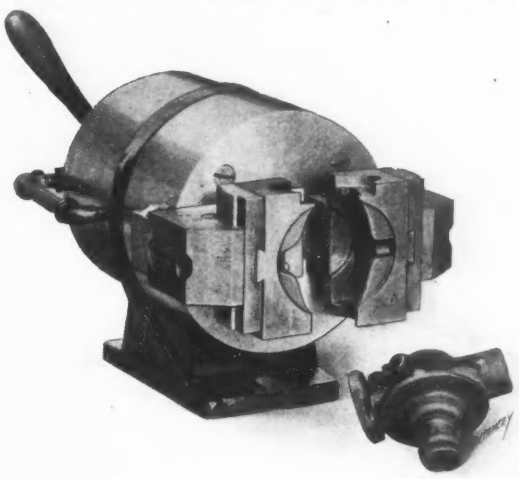


Fig. 2. Opposite Side of Carbureter Body Milling Fixture shown in Fig. 1

running from below, and all the operator has to do is to reach out his hand and draw the lever over; with an air pressure of 80 pounds per square inch, the operator throws between one and two tons' gripping pressure on the work. Owing to the use of this high holding pressure, it was necessary to make parts of the fixture of steel and further strengthen them by carbonizing.

Figs. 3 and 4 show how a ring bevel gear for an automobile rear axle is held. Anyone familiar with the machining and grinding of a bevel gear will know the difficulties that are encountered. In this equipment the gear rests on four points

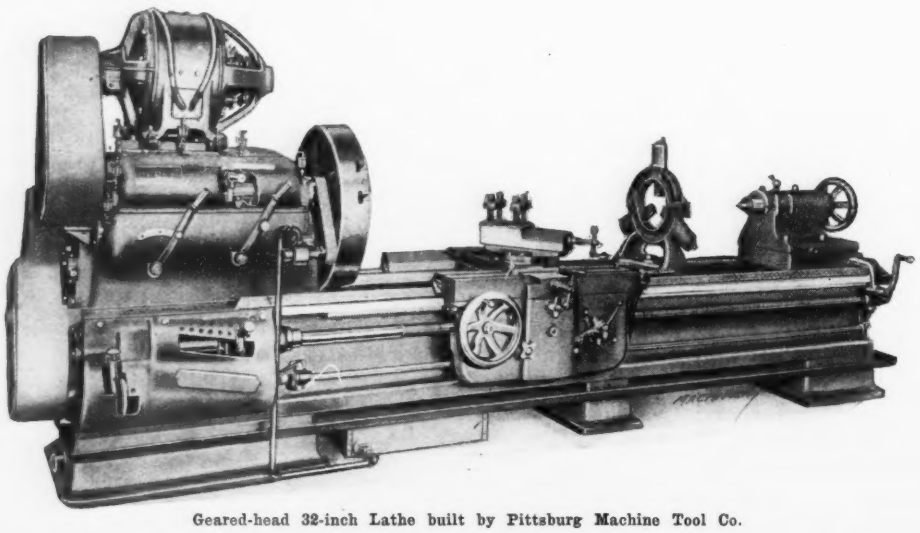
Fig. 3. Detroit Pneumatic Chuck for holding Automobile Ring Bevel Gears

Fig. 4. Detroit Pneumatic Chuck shown in Fig. 3, with Automobile Ring Bevel Gear Blank in Place

made to fit the gear teeth. It will be seen that there are four levers which come down and draw the blank up tight against these resting points; these levers are held on rocking arms on the inside and so constructed that if one should grip ahead of its mate, it stays still until the other lever on the opposite side touches the gear on the outside, and after so doing, the levers draw up and fasten the gear on its bearing points. There is no place where one point on the work is gripped harder than another, thus drawing the work out of shape. This fixture was made for machining the back side of the gear and boring the hole so that the center of the fixture is plugged up, but it can be made, if so desired, with a hole running through the entire spindle of the machine, so that the hole in the work can be water-ground and the chuck still be operated by the air cylinder.

PITTSBURG GEARED-HEAD LATHE

In the accompanying illustration is shown an all-geared-head 32-inch lathe which is a recent product of the Pittsburg Machine Tool Co., Braddock, Pa. These lathes are built in 32- and 36-inch swings, with any required length of bed. It will be apparent from the illustration that they are of extremely heavy construction, and all gearing is of steel, so that



Geared-head 32-inch Lathe built by Pittsburg Machine Tool Co.

these lathes are suitable for the heaviest classes of service. The geared head is furnished with twelve spindle speeds, and there are thirty-six available rates of feed. A new apron has been designed which is of exceptionally heavy and rigid construction. All gears are of steel and all studs in the apron are made of steel, hardened and finished by grinding. The spindle is made of hammered steel, and the ratio of the gearing in the head is 63.5 to 1. Tumbler gears and clutches are made of casehardened steel. These lathes are sold under a guarantee of accuracy of 0.001 inch per foot in the performance of facing and boring operations, and are offered to manufacturers who do accurate machining on heavy castings and forgings. An interlocking arrangement prevents the nut from being engaged with the lead-screw when the longitudinal feed is engaged.

INTERNATIONAL THREAD GRINDER

For truing the threads of thread gages and for similar work where it is required to correct distortion produced by hardening, the International Equipment Co., 1553 S. 58th St., Philadelphia, Pa., has placed on the market a grinding machine, which is shown in Fig. 1. It will be apparent to experienced mechanics that the field of usefulness of this machine includes all internal and external threaded work, as well as cylindrical grinding. This grinder is set up on the lathe after removing the toolpost, and grinding is done by means of a carborundum wheel, which runs at 5500 revolutions per minute. This wheel is first trued to coincide absolutely with the pitch thread to be ground, by means of a diamond set in the attachment shown—the diamond is carried in the ball shown adjacent to the periphery of the grinding wheel, and the wheel truing attachment is graduated to provide for setting it at any angle.

For example, when a U.S.S. thread gage is being ground the wheel is shaped 30 degrees on each side, making it conform

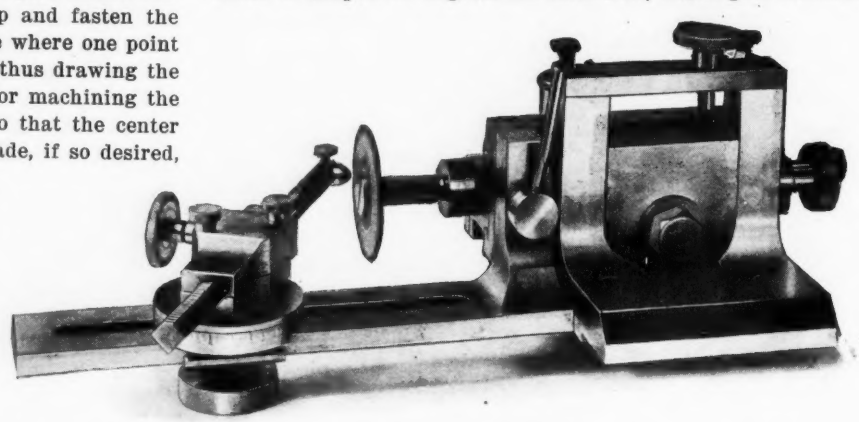


Fig. 1. International Thread Grinder for correcting Distortion of Thread Gages and other Threaded Work

to the exact form of the thread. For special Russian threads on gages which were recently ground on this machine, the wheel was trued 45 degrees on one side and 5 degrees on the other side. This grinder may be employed to true any thread, no matter what the requirements may be, and this applies to taps, hobs, etc., as well as thread gages. It is claimed that this machine is capable of converting any lathe into a cylindrical grinding machine, and that the construction is so rigid that it is impossible for vibration to spoil even the finest work.

Fig. 2 shows examples of an internal and external thread gage ground on this machine. The internal thread gage was cut off from round bar stock, turned, chased, hardened and ground in eight and one-half hours. The external gage is for use on large shell work, and attention is called to the fact that the plain surface grinding was also done on the International thread grinder. Fine taps, hobs, dies, worms and similar threaded parts are being turned out on this machine. The grinder is also used with relieving attachments for relieving taps after hardening.

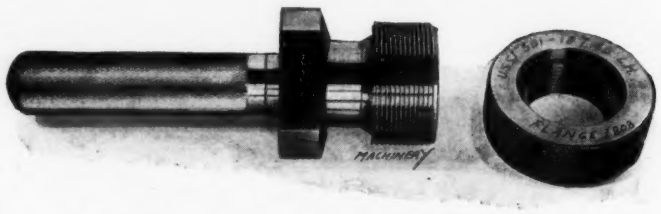


Fig. 2. Internal and External Thread Gages ground on International Thread Grinder

In operating this thread grinder, the spindle on which the grinding wheel revolves must be at all times in perfect alignment with the centers of the lathe. It is therefore adjustable to secure this condition; adjustment is also provided for determining the lead of the thread. A special fiber core is furnished in the end of the driving stud by means of which end play and vibration are taken up instead of being transmitted to the wheel. The driving shaft is independent of the main bearing shaft and allows the wheel perfect freedom of operation. The bronze bearing is indented with right- and left-hand, as well as straight, oil-grooves, which equalize the flow of oil and permit the spindle to run constantly in oil.

When grinding coarse threads the device is tipped sufficiently so that the heel of the wheel will not interfere with the course of the thread. Two oil-cups are furnished, one for the driving shaft and the other for the main bearing shaft. An ingenious method is provided for attaching and detaching the wheel dresser, which renders the operation practically instantaneous. This is accomplished by means of an interrupted screw provided with a handle. There is no lost motion in the rack diamond holder, because any lost motion is taken up by means of a spring pressure exerted upon the rack. This rack meshes with a pinion operated by means of a handwheel which feeds the diamond the required distance. The entire dressing attachment is movable back and forth by means of a releasing nut.

Fig. 2. Cone-driven 17-inch Lathe built by National Lathe Co.

NATIONAL LATHES

The National Lathe Co., 15 W. Second St., Cincinnati, Ohio, is now building the 18-inch geared-head lathe illustrated in Fig. 1. On the National geared-head lathe there are only twelve gears in the head. All the back-geared drive gears are five pitch and the direct geared drive gears are six pitch. All the gears are made of steel, and there are only two shafts besides the spindle. These shafts run in bronze journals in the bottom of the head. There are no journals suspended in the top of the head. This is said to insure perfect alignment and rigidity. The shafts are of 40-point carbon steel, ground to fit. The gears are cut with special cutters, giving them as perfect a mesh as possible.

The design has been worked out in such a way as to insure strength and long wearing qualities, and the simplicity of the design makes it possible for the operator to change speeds with great rapidity. With a two-speed countershaft a total of sixteen speed changes are obtainable, ranging from 12 to 330 R.P.M., or eight forward and eight reverse speeds. The stopping and starting lever is conveniently located so that the operator does not have to change his position when he is checking or calibrating a piece of work. When the clutch lever is shifted, all the gears in the head are stopped. It is so designed that only the gears that are working are in mesh, the gears not required to operate being thrown out of mesh. The advantages in this arrangement are obvious.

The drive is of the single-pulley type; the pulley is 12 inches in diameter, and runs at 330 R.P.M. It carries a 4-inch belt, which gives ample driving power. A friction clutch is mounted on the driving pulley shaft, and is operated instantaneously with a single lever. The countershaft clutch pulleys are 12 inches in diameter and run at 240 R.P.M. They carry a 4-inch belt. The spindle speeds range from 12 to 330 R.P.M. At no time do the gears drive at a greater speed than the driving pulley, and the greatest speed reduction is 28 to 1.

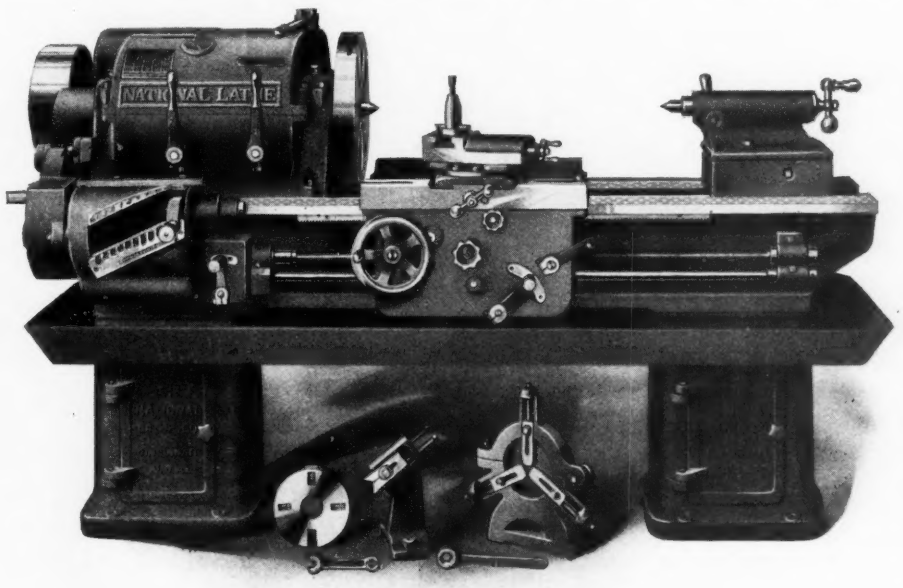


Fig. 1. Geared-head 18-inch Lathe built by National Lathe Co.

National Cone-driven Lathe

In Fig. 2 is shown a 17-inch engine lathe with double back gears and a three-step cone pulley, which is another recent product of the National Lathe Co. The bed of this machine is firmly braced for its entire length and designed to absorb vibration incident to heavy work. The headstock is also ribbed. The spindle is hollow and made of a special carbon steel and finished by grinding. The centers are No. 4 Morse taper, and the boxes are made of phosphor-bronze, with means of compensating for wear. A double-walled apron is provided, so that all important shafts and studs may have a rigid outboard bearing. Control of all feeds is within convenient reach of the operator, and an interlocking device makes it impossible to engage the lead-screw and feed-rod at the same time. The screw-cutting mechanism is of the quick-change gear type, and all available feeds are obtained by the movement of one lever. Speeds from 3 to 64 per inch are available on standard lathes, and from ½ to 15 millimeters on the screw-cutting lathe. The range of available feeds is from 0.006 to 0.128 inch per spindle revolution.

The lead-screw is 1 5/16 inch in diam-

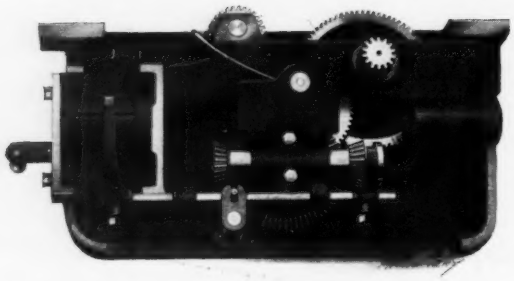


Fig. 3. Apron of National Geared-head Lathe shown in Fig. 1

eter, and is made of special carbon lead-screw stock. It is chased by means of standard and metric master lead-screws, either metric or standard pitch screws being furnished, as desired. In chasing threads, the apron half-nuts engage at the proper point, thus guarding against error and saving time. The feed-rod is gear-driven and enables the operator to obtain a large range of feeds, from the coarsest to the finest. The compound rest is rigidly constructed and fitted with full length taper gibs having end adjusting screws. The swivel is made completely circular, is graduated in degrees, and firmly clamped to the cross-slide. A tailstock of the National Lathe Co.'s offset type allows the compound rest to be placed parallel with the bed. The tailstock is provided with set-over screws for taper turning operations. Provision is made for firmly locking the carriage for cross-feed work, and the carriage is gibbed to the bed at both the front and back; it has a wide bearing for the slide-rest, with a large vee at the front and back.

HARRIS AUTOMATIC MULTIPLE-PLUNGER PRESS

For the rapid automatic production of stamped, perforated and embossed sheet metal parts, the H. E. Harris Engineering Co., 1041-1055 Broad St., Bridgeport, Conn., has developed the machine illustrated and described herewith. It is a multiple-plunger press especially adapted for the manufacture of eyelets, snap fasteners, pencil tips, primers, percussion caps, thimbles, buttons, ferrules, automobile grease and oil-cups, fuse caps, boxes and covers for medicines and toilet articles; in fact, these machines can be used for the manufacture of almost any part that can be produced from sheet metal by several punch press operations. Machines of this type are supplied for doing both large and small work. These machines are very rapid in operation, producing from 35,000 to 80,000 parts per day of ten hours, allowing time for repairs, setting up, sharpening tools, oiling, replenishing the stock, and other legitimate causes of delay or stoppage. This large variation in output covers all classes of work, the output depending upon the kind of material used, its thickness, the depth to which it has to be drawn and other factors directly due to the nature of the work. The number of revolutions per minute at which the cam-shaft should run (or strokes of the plungers per minute) varies from 65 on heavy, deep-drawn work to 150 on light, shallow work.

Automatic Operations Performed

This machine will automatically cut a blank from sheet metal and carry the work along for the successive operations under other plungers, performing such operations as piercing, forming, drawing, trimming, light stamping or embossing, etc., and completing the part without manual handling. The basic principle of the machine has been used for forty-five years, and, in fact, most of the manufactured articles mentioned are made by older forms of this machine. The common trade name for a machine of this kind is "eyelet machine." In the new design there are improvements which were developed and added in 1916 and 1917. The frame is offset at the left-hand side, and provision is made for an extra die and for a double punch to be carried by the last plunger. In this way the Harris automatic multiple-plunger press will perform one more operation than the number of plungers. This is a distinctive feature of the machine. On all other machines, the number of operations is the same as the number of plungers. This makes it unnecessary to follow the general practice of providing one more plunger than is actually needed, for if it becomes advisable to add an additional operation, such as stamping a name or trademark, or any other operation which becomes desirable after first planning, the means for taking care of it in the machine are thus provided. The popularity which this machine has attained is due to the fact that all the operations are simultaneous; that is, with each revolution of the cam-shaft, each of the plungers performs an operation on the parts going through the press. The speed of operation and methods of performing the work do away entirely with the necessity of annealing parts between operations.

Adapting the Machine for Different Work

The weight of the machine, the throw of the cam and other details are arranged to suit the parts to be manufactured in the press; likewise, the number of plungers is varied to suit the number of operations required. The machine consists of a heavy main frame carrying a number of press plungers, which, in turn, carry the different punches for blanking, embossing, piercing, drawing, etc. The plungers are operated by a cam-shaft that determines the timing and throw. The bolster fitted on the bottom part of the main frame holds the different dies to suit the punches and carries the transfer slide. The plungers are returned to their upward position after operating upon the part, by the same shaft but with a separate set of cams. This is done by the adjustable horizontal members shown above the cam-shaft, which may be seen between the cam-shaft and the upper cross member of the frame, and connected to the plungers by means of the vertical lifting rods at the back. From the cam-shaft is geared a vertical crankshaft, which operates the transfer slide from right to left. This slide carries the work along from the first plunger at the right-hand side to the second plunger, and from there to the third plunger, and so on, there being a piece under each plunger at each stroke of the press. The stock is passed underneath the first plunger from a reel shown on the front of the machine, by means of a roll feed on the back, and the blank is punched out in the first operation.

Determination of Size

The size of the machine is determined by the depth of the parts to be drawn or embossed, and the diameter or width of

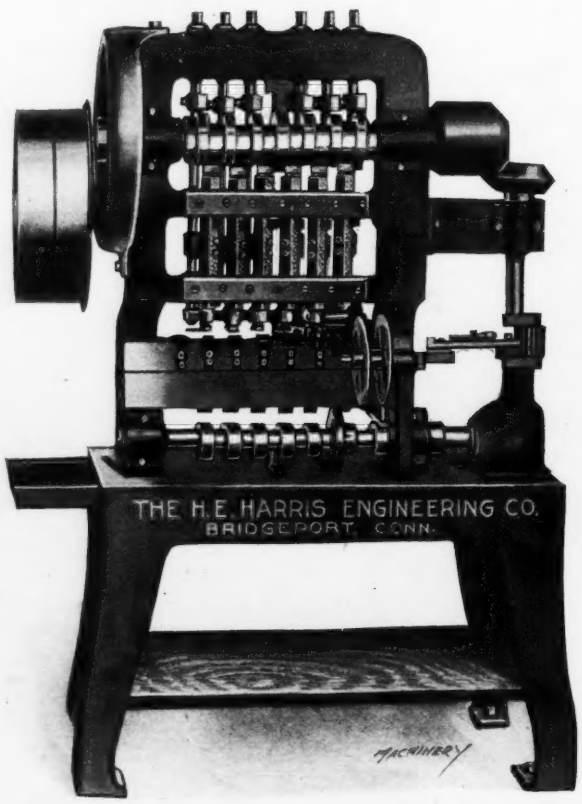


Fig. 1. Automatic Multiple-plunger Press built by H. E. Harris Engineering Co.

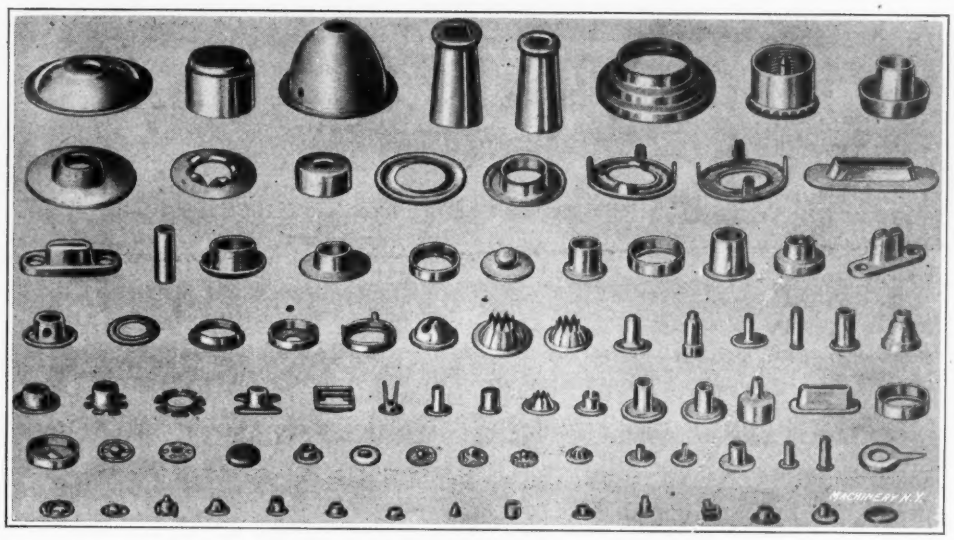


Fig. 2. Examples of Work done on Harris Multiple-plunger Presses

the blank. These machines are built with from three to twelve plungers, although these extremes are rarely used, from four to seven plungers being most generally employed; these, with the provision before stated for an additional operation, cover the entire range usually required from these machines. In manufacturing parts, the machines operate as follows: The metal, which is in strip form, coiled, is placed on the reel in front, passes through a lubricating pad and through a stripper over the blanking die to a feed roll mechanism in the back. This mechanism is operated by an intermittent ratchet, timed so as to coordinate with the operation of the press. While the strip stock is at rest in this position, the first plunger blanks out the piece and carries it through the die to a pocket in the transfer slide, a reel at the back reeling up the scrap stock after it leaves the feed rolls. The transfer slide moves from right to left, by the action of the vertical crankshaft, the movement being equal to the center distances between the plungers. This action carries the blanked piece in the pocket in the transfer slide, under the second plunger, which carries the forming punch, and the second operation is performed by the punch in the second plunger, drawing the blanked piece through the transfer slide and into the first forming die. The transfer slide now moves back from left to right into its first position, so that it can move again from right to left, carrying the second blanked piece from the first plunger to the second position, and at the same time carrying the cupped piece from the second position to the third position.

This operation is repeated at each stroke of the press, until work has been carried along to the last plunger, when it is ejected and carried through a tube into a box or pan. The work is returned from the dies (with the exception of the first one) to the transfer slide, where it is dropped into a pocket by vertical ejector plungers operated by the lower cam-shaft, which is geared to operate in synchronism with the upper cam-shaft through the medium of bevel gears. This will be seen in the illustration at the right of the machine. These lower plungers push the work up out of the die at the proper time into the fingers of the transfer slide. The transfer slide is fitted with these carriers or fingers for each station except the first. They take hold of the piece like the thumb and index finger of a person's hand.

Service

The machine is thus fully automatic in its operation, the operator only having to keep the stock reel supplied with stock and remove the boxes of finished work and small piercings, if any, replacing them with empty boxes. One attendant can take care of a dozen or more machines. The cams on the main cam-shaft at the top of the machine are made of tool steel, hardened to the proper temper, and operate upon hardened bumpers which are adjustably fitted to the upper end of the plunger, to control the setting of the tools. The upper and lower cam-shafts and the crankshaft are also made from tool steel, forged before machining. The multiple plungers are machined from tool steel, ground perfectly square and true, and are fitted with the utmost accuracy of spacing, alignment, and with smoothly fitted sliding surfaces to the frame of the machine.

The dimensions of the machines most generally used for the usual run of eyelet and fastener work are as follows: number of plungers, four, six and seven, with provision for five, seven and eight operations; movement of plungers, 1⅜ inch; distance between plungers, 2½ inches; maximum diameter of part, 1¼ inch; and maximum depth of draw, 9/16 inch. For machines with the following numbers of plungers the floor space and net weight are as follows: Four plungers, net weight, 2000 pounds; floor space, 40 inches by 52 inches. Six plungers, net weight, 2215 pounds; floor space, 40 inches by 58 inches. Seven plungers, net weight, 2375 pounds; floor space, 40 inches by 64 inches. Fig. 3 illustrates how the machines should be arranged to permit one attendant to care for a dozen or more.

LANGELIER BENCH TAPPING MACHINE

A vertical tapping machine, built in bench and floor types with a capacity for tapping holes up to 1/4 inch in diameter in brass and up to 3/16 inch in diameter in steel, has recently been placed on the market by the Langelier Mfg. Co., Providence, R. I. This machine embodies several interesting features in its design, among which the following are worthy of special mention: An automatic reversing mechanism causes the tapping spindle to reverse its direction of rotation instantly at a predetermined depth, without depending in any way upon the resistance of the tap to effect the reversal. This feature is specially advantageous when tapping thin stock with fine taps, or for blind tapping. The reverse is effected by adjusting a depth stop. These adjustments may be made very quickly and simply.

So effective is this automatic reverse that, on tests, ten steel pieces, 3/16 inch thick, were tapped complete in one minute, by a 3/16-inch tap operating at 800 revolutions per minute.

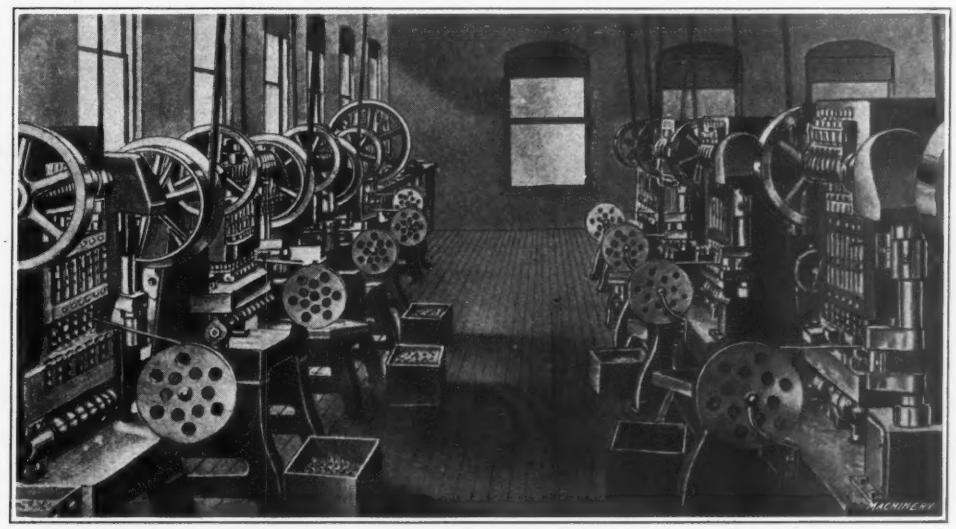
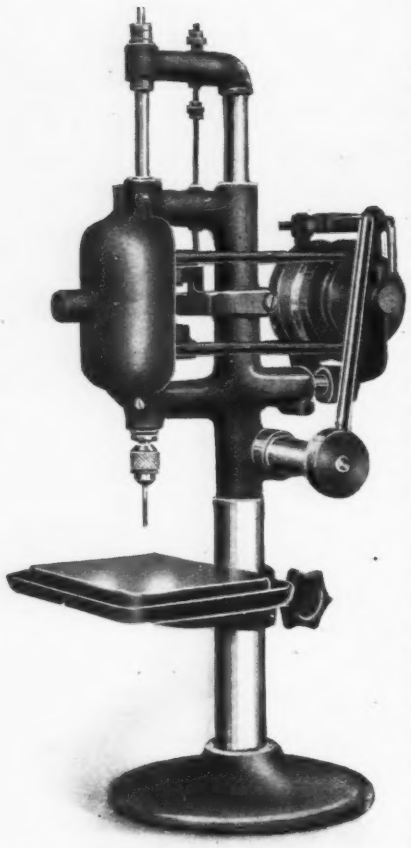


Fig. 3. Arrangement which enables One Operator to attend to Twelve or More Presses



Vertical Tapping Machine built by Langelier Mfg. Co.

Correspondingly higher production is obtainable in brass or with smaller taps. The spindle is floating, with all unnecessary weight and load removed, and is double-splined for correct balance at high rotative speeds. It is driven into the work in much the same manner as the spindle of the Langelier sensitive high-speed drilling machine, securing marked reduction of tap breakage, especially when fine taps are used. The spindle is mounted and carried in a feed yoke actuated by a hand-feed lever, and is entirely independent of the reverse mechanism, which is mounted on the machine column.

The tapping spindle may be fed down by depressing a foot-treadle provided for the purpose, and further feed is accomplished by continuing the pressure upon the foot-treadle or by lowering the hand-feed lever. The construction employed throughout relieves the spindle of all load beyond that of its chuck and tap. Ample driving power is delivered to the tapping spindle. The drive is transmitted to the machine by a 1-inch belt on 4½-inch diameter tight and loose pulleys. These pulleys are mounted on a common horizontal shaft, which also carries one bracket at the back of the machine column. This shaft also carries one idler and one tight pulley, grooved for a ⅜-inch diameter round, endless belt. The bracket is adjustable backward and forward, to maintain the proper tension for the round belt, which is looped over the forward and reverse pulleys by the over and under method.

A clutch mounted between the spindle driving pulleys, actuated by the snap fork shown, engages either the forward or the reverse pulleys. The depth stop on the yoke governs the time of the throw, and a belt shipper for the tight and loose pulleys is equipped with a snap catch which holds the belt positively on the desired pulley. With this belt shipper there is no possibility of the belt trailing from one pulley partly onto the next. The table, adjustable vertically and with radial movement, is of ample proportions to hold all ordinary sizes of jigs for the work done on this machine. The working face of the table is planed true and square with the spindle and has an oil rim on four sides. For tapping large quantities of parts, where the pieces are to be clamped or jigged in a stationary fixture and the holes to be tapped are not likely to come all exactly in the center of the work, an auxiliary flexible extension spindle is furnished, which is gripped by the chuck on the regular machine tapping spindle, and this permits the tap readily finding its own center and materially reduces tap breakage.

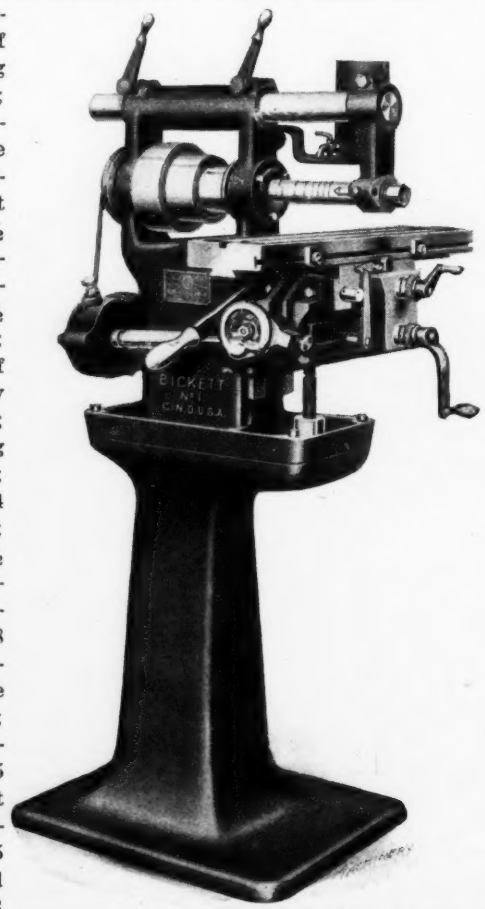
The principal dimensions of the machine are as follows: height, 31 inches; size of table with oil rim, 6 1/2 by 9 inches; distance from chuck to table, 0 to 7 3/4 inches; distance from spindle to column, 3 7/16 inches; feed of spindle, 3 1/8 inches; speed based on 3/16-inch tap, 800 revolutions per minute; size of tight and loose pulleys, 4 1/2 inches by 1 1/8 inch; net weight of machine, 240 pounds; and bench space occupied, 15 1/2 by 10 inches.

BICKETT HORIZONTAL MILLING MACHINE

In the accompanying illustration is shown a No. 1 horizontal milling machine arranged for power and hand feed, which is a recent product of the Bickett Machine & Mfg. Co., 1118 Richmond St., Cincinnati, Ohio. It will be apparent from the illustration that this machine is of sturdy construction. In addition to its use as a manufacturing machine, it is suitable for use in jobbing machine shops, as it is adapted for both light and fairly heavy milling. Such operations as end-milling, keyseating, oil-grooving, face-milling, splining, T-slotting, gear-cutting, straddle-milling, and many similar operations can be performed. The longitudinal feed of the table is effected by a gear and rack which provide a rapid movement by means of a hand-lever, while the power feed is transmitted through a series of worms and worm-wheels.

The spindle is made of crucible steel finished by grinding and mounted in Gurney ball bearings. At the front end there is a No. 9 B. & S. taper hole for the cutter-arbor, and the hole extending through the spindle is ⅞ inch in diameter. Six spindle speeds are obtainable, and the machine may be run at 2500 revolutions per minute for continuous operation. Reversible power feed is provided for the longitudinal movement of the table. This mechanism is geared to feed 0.003, 0.006 and 0.009 inch per revolution of the spindle. The drive is by a one-inch leather belt running on three-step cone pulleys and thence through a set of tumbler gears and a universal driving shaft to a worm and wheel under the table. An automatic trip releases this worm at the end of the cut and the feed of the table can be readily reversed. The power feed can be changed to hand feed, and the hand feed is arranged to operate either by means of a geared lever or a hand-wheel. The knee is of box-type construction, accurately scraped and aligned and held to the column by a substantial adjustable gib. It is raised and lowered by means of an Acme thread elevating screw.

Among the important dimensions of the machine the following may be mentioned: diameter of hole through spindle, ⅞ inch; distance from center of spindle to bottom of arbor support arm, 5 1/32 inches; size of arbor, 9 inches long by 1 inch in diameter; diameter of arbor spacing collars, 1½ inch; maximum distance from face of column to arbor support bracket, 11½ inches; diameter of cone pulley steps, 3, 4½ and 6 inches; face width of cone pulley steps, 2¼ inches; width of driving belt, 2 inches; size of table, 24 by 5½ inches; size of T-slot, ½ inch wide; maximum longitudinal feed, 18 inches; maximum transverse feed, 5 inches; maximum vertical feed, 5 inches; height of machine without pedestal, 25 inches; and base, 9½ by 18 inches.

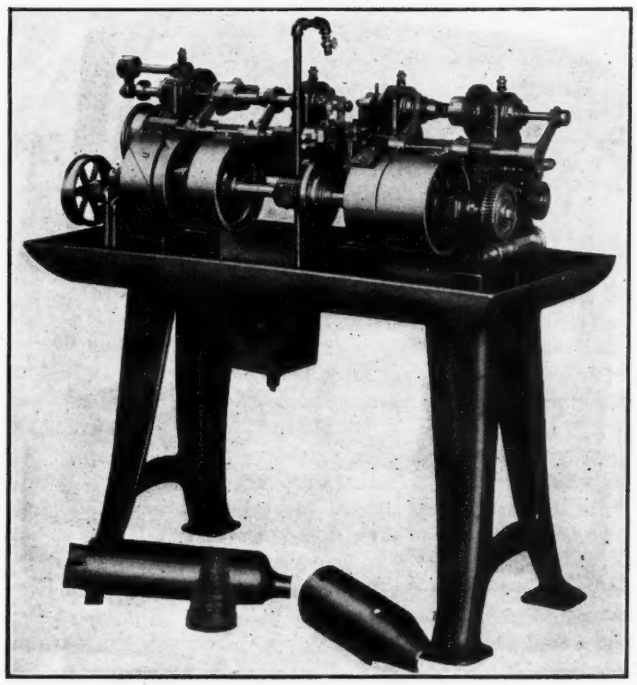


Horizontal Milling Machine built by Bickett Machine & Mfg. Co.

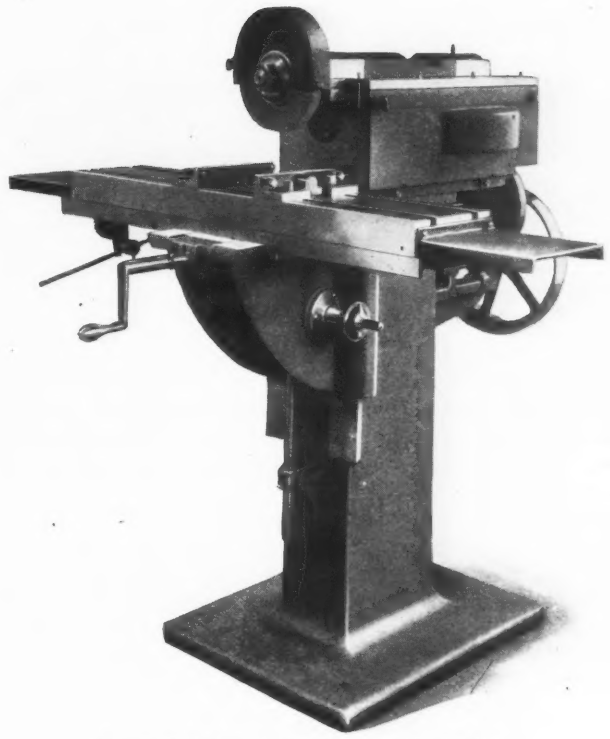
DETROIT AUTOMATIC PIN MACHINE

One of the recent products of the Detroit Tool Co., Detroit, Mich., is a full automatic screw machine of unusual design, which is styled a "pin machine." This machine is so constructed that it can only be used for cutting-off and turning operations, and at the present time it is built to take stock up to ⅜ inch in diameter; but it is the intention later to bring out a ⅝-inch machine of the same design. Pieces made on this machine are finished on both ends, making it unnecessary to perform a subsequent burring operation. These machines are rapid and accurate in operation, holding work within close limits. They can be used for making any small pieces from steel or brass which do not have to be threaded or drilled, and can also be fitted up to take care of pieces on which a rolled thread is required. Reference to the accompanying illustration will show that this machine has both a head- and tail-spindle. The stock is fed through the head-spindle in the usual way, and after coming in contact with the feed stop, it is gripped by the tail-spindle, which revolves at the same speed as the head-spindle, both being geared to the same driving shaft. The tail-spindle holds the work rigidly until the piece is cut off.

Owing to the fact that work is held in both spindles, it cannot chatter during the cutting-off and forming operations. This is the means of greatly increasing rates of production, because more pieces can be cut off for each grinding of the tools and the feed of the tools per revolution can be increased. The cross-slides are arranged to work independently of each other, enabling the front and back tools to be used at the same time. Fourteen change-gears are supplied with each machine, which allows the timing of the cams to be arranged with a minimum of lost motion. Driving belts for the machine and the pump are located at one end of the machine, where they are away from the cutting oil. The cam-shaft is located at the rear, where it is accessible for changing cams, and it can be thrown in and out of motion at any time by means of a clutch lever located at the front of the machine. A special feature of this machine is the construction of the spindle bearings, which are lined with phosphor-bronze to provide for employing the highest practicable spindle speeds in turning brass. The spindle bearings are made to fit a tapered steel sleeve to provide for taking up wear, this construction enabling each bearing to be adjusted and replaced without disturbing the alignment of the spindle. Ample oiling facilities are provided, and all exposed gears are protected by guards. Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York City, will have the United States sales agency for this machine.



Automatic Pin Machine made by Detroit Tool Co.



Improved Design of "Hartford" Surface Grinder

"HARTFORD" SURFACE GRINDER

The National Machine Co., Hartford, Conn., has brought out an improved design of surface grinder. This machine, like the preceding model (described in MACHINERY, September, 1915), is a horizontal traversing-wheel type, intended for such work as finishing the flat surfaces of dies, punches and other hardened parts. The grinding wheel is carried by a heavy ram or slide, which is gibbed to the stationary head. The ram and wheel has a maximum traversing movement of 12 inches, and the motion may be reduced in accordance with the width of the work by adjusting the crank stud in its slot. The position of the ram may be varied by adjusting the ram stud, to bring the wheel in the right location relative to the work.

The platen or work-table may be adjusted vertically or laterally, and it has an automatic lengthwise feeding movement in either direction. The maximum feeding motion is 1/16 inch for each complete stroke of the ram. This motion, which occurs when the wheel has completed its stroke, may be reduced any required amount for obtaining a fine finish. The saddle carrying the table is dovetailed and gibbed to the top of the knee, which is dovetailed and gibbed to the face of the column or frame. The knee may be locked in position by means of a binder screw. The elevating screw is equipped with a graduated dial reading to thousandths of an inch.

The spindle runs in phosphor-bronze bearings, and it is a steel forging having a diameter in the bearings of 1½ inch. The wheel hood has a hinged front, so that the wheel is accessible. Work may be held on the machine table either by adjustable clamps furnished with the machine or by regular machine vises, special holding fixtures, or magnetic chucks. The work-table measures 8 by 37 inches, and it has a longitudinal movement of 30 inches, a traversing movement of 7 inches, and a vertical movement of 14 inches. The maximum distance from the center of the spindle to the table is 16 inches. The water attachment consists of a special table, pump and tank, with the necessary piping and valves.

HOUSTON, STANWOOD & GAMBLE LATHE APRON

In an ideal lathe apron design, ample strength should be provided to move the carriage along on its ways under any rate of feed and depth of cut which the headstock is capable of pulling. The accompanying illustrations show a lathe apron recently developed by the Houston, Stanwood & Gamble Co., of

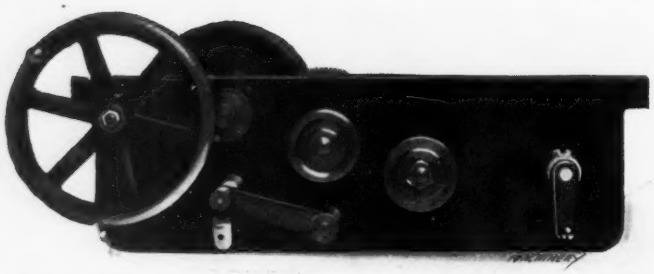


Fig. 1. Improved Lathe Apron recently developed by Houston, Stanwood & Gamble Co.

Cincinnati, Ohio, which possesses features giving it ample driving power, strength and durability. All gears are made of steel to afford ample strength to withstand unexpected and unusual strains imposed upon the gearing in aprons on large lathes on which heavy turning and boring operations are performed.

Figs. 1 and 2 show front views of this lathe apron, and it will be noticed that use is made of a positive toothed clutch in place of the usual friction clutch. Disks in the initial drive are connected with a shearing pin, as is clearly shown. It is claimed that the positive clutch does not slip, and owing to the slight pressure required to hold the clutch closed, is easily released. With this positive feed clutch there should be a weak point to protect the feed mechanism from breakage in case the carriage were accidentally fed against the tailstock, headstock, steadyrest or other obstruction. A shearing pin,

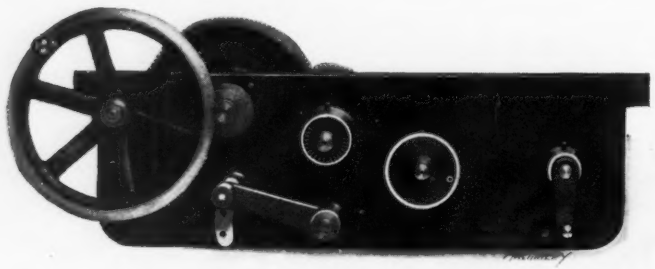


Fig. 2. Houston, Stanwood & Gamble Lathe Apron partially disassembled

to which reference has been made, provides such a weak point in the train of mechanism. It will also be noted that the rack pinion can be withdrawn from the rack for thread cutting and that the nut for the lead-screw is opened and closed in the usual manner. The customary reverse lever for shifting double bevel gears is provided, and the clutch for cross-feed is attached to the carriage. This clutch is not shown, but it is of the positive toothed type. Attention is called to the big reduction from handwheel to gear in the lathe, which insures that the carriage will be easily moved by hand.

Fig. 3 shows the back of the apron, and here attention is called to the broad-faced, coarse feed-rack pinion. There is an outer bearing for the rack pinion, that is, this pinion is not overhung. The large bevel gear also has an outer bearing, although this is hidden from view. A capillary wick oiling system of lubrication for the bearings is furnished in the rear plate of the apron. The Houston, Stanwood & Gamble Co. employs this apron, with slight modifications according to size, on all its standard engine lathes built in sizes from 30 to 60 inches swing.

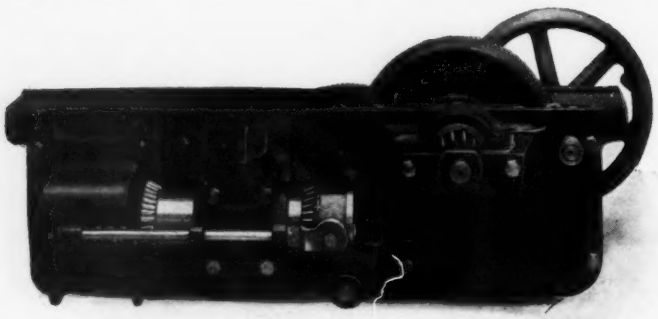


Fig. 3. Opposite Side of Lathe Apron, showing Arrangement of Gearing

RELIANCE ELECTRIC MOTOR

It has been the experience of some electric motor manufacturers that their business is largely divided into two groups. In one of these the service is severe, while in the other only a moderate service demand is made of the motor. The latter type of service is by far the more general, and many manufacturers have specialized in the construction of motors adapted for moderate service. To meet the demand for a rugged heavy-duty general-service motor, the Reliance Electric & Engineering Co., 1056 Ivanhoe Rd., Cleveland, Ohio, has developed a Type T machine, which is illustrated and described herewith. Machinery builders and users have experienced difficulty in mounting motors on their machines,

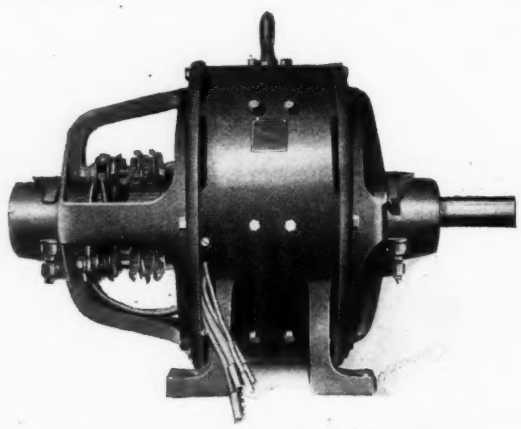


Fig. 1. Reliance Type T Heavy-duty Electric Motor

and to overcome this the new Reliance motor has been provided with heavy feet cast integral with the motor frame, wide ribs being carried up from the feet to the frame so as to give effective support. The motor frame has four laminated main poles which are securely fastened to the frame by capscrews. The flat section at the pole tip provides a surface against which the coil can press snugly without danger of wear. The field coils are insulated and provided with protective features to meet hard service conditions. Double cotton covered wire is used for the commutating coils, which are wound in a form, dipped in insulating varnish and baked. They are assembled in press board and fiber spools of the same kind that are used for the main field coils.

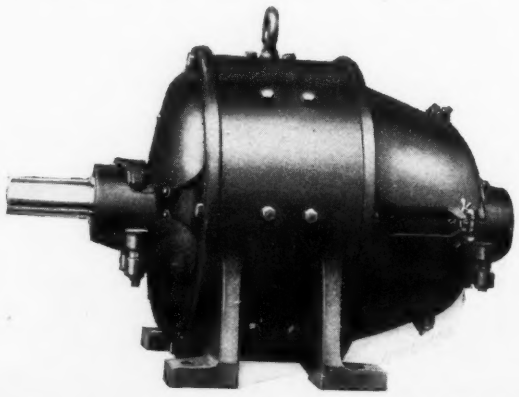


Fig. 2. Opposite Side of Reliance Motor of Fully Enclosed Dustproof Type

The bearings are cast-iron shells babbitted with metal containing over 70 per cent tin and only a trace of lead. Babbitt liners are locked in place by depressions in the cast-iron shells. In addition to the "oil throws" on the armature shaft, other precautions are taken to keep the oil in its proper place. Spiral oil-grooves insure proper distribution of the oil, and the bearing is shouldered in the end bracket and held against rotation by a large dowel screw under the oil-hole cover. When desired, split bearings may be supplied at the pinion end to provide for taking out the armature without removing the pinion. All armature cores are built up of electrical steel punchings insulated with core plate varnish. These punchings are mounted on a cast-iron spider and securely keyed to it. To insure tight cores, the laminations

are pressed together under five to ten tons pressure and securely held between two substantial end flanges. The shaft is made of forged high-carbon steel and finished to size by grinding. Double cotton covered wire used for the armature coils is wound on a form and dipped in insulating varnish, after which it is baked. The commutator is mounted on an extension of the armature spider and forced on under approximately four to five tons pressure, provision against rotation being provided by a round key. The commutator is of the cap-screw type on which the screw heads are accessible from the outside. These and other features of the Type T Reliance motors adapt them for those classes of heavy service for which they have been especially designed and built.

BICKNELL-THOMAS THREAD LEAD INDICATOR

This tool fills the demand for a simple but accurate device for testing the lead of both external and internal screw threads. The accompanying illustrations clearly show the

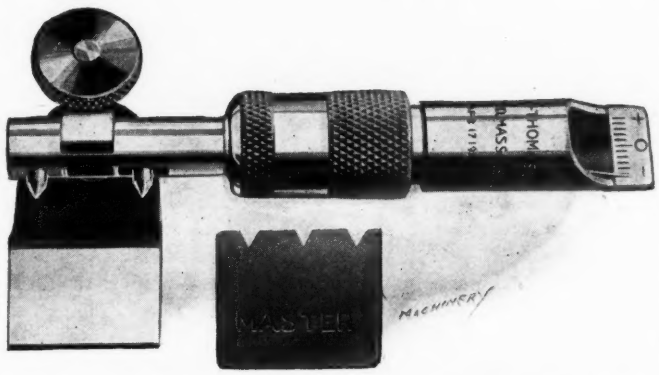


Fig. 1. Thread Lead Indicator and "Master" made by Bicknell-Thomas Co.

construction and method of using the instrument for measuring the lead on the screw and inside the tapped hole. In use, the tool is held in one hand, preferably the left, and the screw is pressed against the two points, which are spaced ¼, ½ or 1 inch apart, as desired. If the lead of the thread is normal the indicator needle will register zero; if the lead is short the needle will show on the minus side; if long, on the plus side. Each line of the graduation represents 0.001 inch.

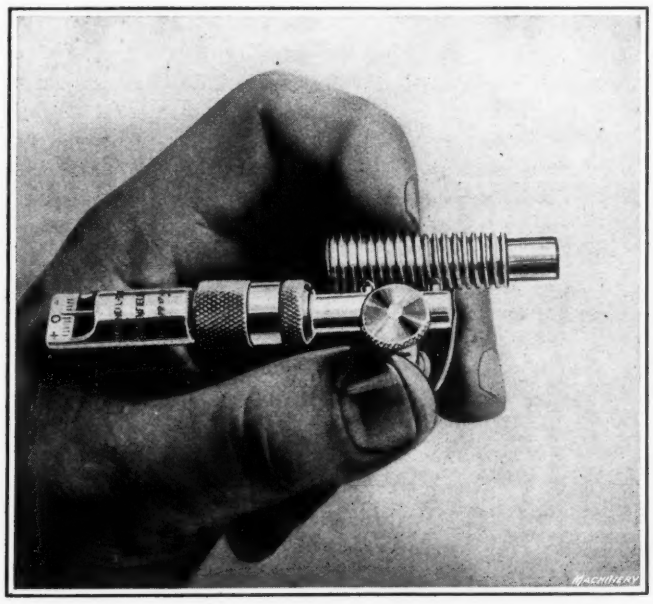


Fig. 2. Thread Lead Indicator in Use testing an External Thread

The table on which the screw rests in testing is adjustable to accommodate screws of any diameter. For internal measuring, the table is removed merely by loosening the thumbscrew and drawing it off. The end of the instrument containing the point is small enough so that tapped holes as small as ½ inch in diameter can be tested and, of course, from that

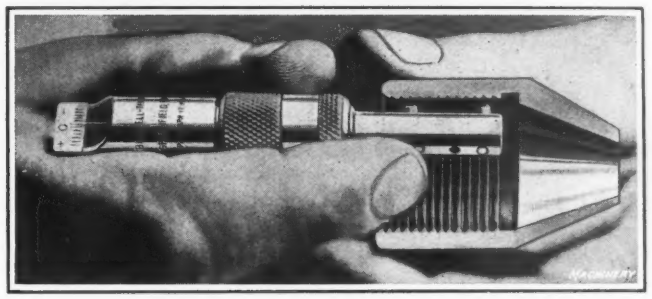


Fig. 3. Thread Lead Indicator in Use testing an Internal Thread

up to any size. This is a feature which is not found on any other lead tester and is of the utmost importance in making sure that the lead of the thread on both the screw and in the tapped hole are the same. A master is furnished with each gage so that the operator may be sure at all times that the needle point is on zero when the gaging points are spaced correctly. If it is necessary to test threads with odd pitches, as 13 threads to the inch, a master can be furnished to which the indicating point can be adjusted. This tool is one of the latest products of the Bicknell-Thomas Co., Greenfield, Mass.

HISEY-WOLF ELECTRIC GRINDERS

The Hisey-Wolf Machine Co., Cincinnati, Ohio, is now building a line of portable electric surface grinders. These are made in twenty different styles having capacities of one-quarter, one-half, one, two and three horsepower. To meet the requirements of different shops, grinders may be obtained with direct-current motor, alternating-current motor, or the so-called "universal" motor suitable for operation on either alternating or direct current. The direct-current motor is of the compound-wound type and operates at a constant uniform

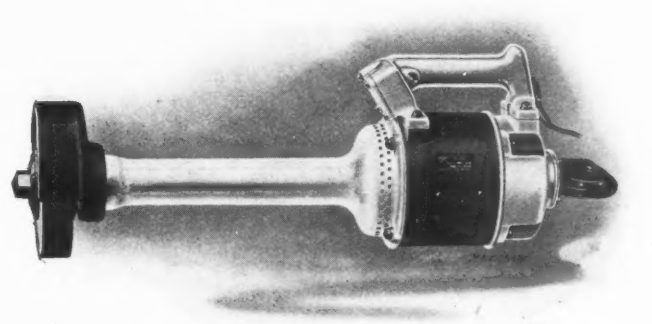


Fig. 1. Hisey-Wolf Portable Electric Grinder with Long Spindle and Guarded Wheel

speed. It is provided with forced ventilation for continuous service at capacity and will not run hot. The alternating-current motor is of the squirrel cage induction type and is regularly supplied for sixty-cycle, single, two- or three-phase circuits. For operating from any lamp socket on the lighting circuit, single-phase machines are required. Two- or three-phase machines are employed for operation on corresponding power circuit lines and cannot be operated from lamp socket connections. If one phase of the line of a two- or three-phase system is equipped with lamp socket connections, a single-phase grinder can be operated from it. The universal motors are primarily designed for operation on twenty-five-cycle, single-phase, alternating current with effective grinding speeds not obtainable with the induction type alternating-current motors at this low frequency. These universal motors will operate equally well on either direct current or single-

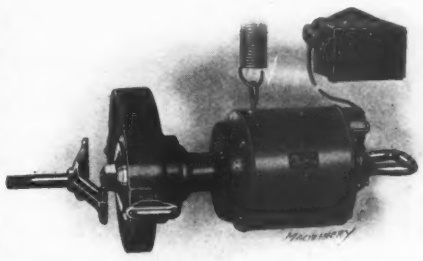


Fig. 2. Hisey-Wolf Portable Electric Grinder with Removable Handle in Line with Spindle

phase alternating current up to sixty cycles. The motor is designed for operation from lamp sockets.

Aside from the different types of motors furnished with these grinders, the design of the different machines comprising the line is essentially the same. S. K. F. ball bearings are used throughout, and they are so mounted that grinders can be operated with the shafts in any position. The machines with extended spindles are equipped with center bearing supports, the bearing nearest the grinding wheel being designed to take all working strains and stresses. The bearings are completely enclosed to protect them from dust and grit, and where necessary felt protector washers are provided. Provision for efficient lubrication is one of the important features embodied in these portable grinders. The bearings are filled with a semi-fluid grease which provides proper lubrication for a period of several months. Each machine is fitted with a quick-acting switch of a type well suited to the current and size of grinder on which it is used. The switch is conveniently located in the motor frame and can be operated without requiring the operator to lose his grip on the handle. All switches are completely enclosed to insure protection at all times, regardless of the position of the grinder.

The spindles used in these grinding machines are made of steel and accurately ground to size. Extended spindle grinders are made with a two-piece shaft mounted in a double set of ball bearings. The handles are mounted according to the way experience has proved to be best adapted for each size and style of machine. Grinders of two- and three-horsepower capacity are designed with handles suitable for operation by one or two workmen. The wheel guards are made of steel to insure adequate protection, and they are adjustable so that they can be placed at a convenient angle. The grinding wheels regularly furnished on these machines are of a grade and grain which experience has shown to be well adapted for each size and type of machine.

OAKLEY CUTTER AND TOOL GRINDER

The Oakley Machine Tool Co., Cincinnati, Ohio, is now building a No. 2 cutter and tool grinder, which will rapidly

Fig. 1. No. 2 Cutter and Tool Grinder built by Oakley Machine Tool Co.

and accurately sharpen any style of milling cutter that comes within its range. This grinder may be furnished as a universal machine equipped with attachments for surface, cylindrical and internal grinding, and when so equipped it will handle all work that comes to the average tool-room, such as grinding jig bushings, straightedges, snap gages, reamers, form tools, etc. A feature of the design is that the arrangement of handwheels and levers gives unusual convenience of operation. The base has a heavy pyramid construction, affording a solid bearing on the floor. Means are provided for securely bolting the column to the base, and a dovetail bearing is provided on the column to support the knee. A swivel motion of 180 degrees each way is provided for the wheel-head on the column, and the massive construction absorbs vibration.

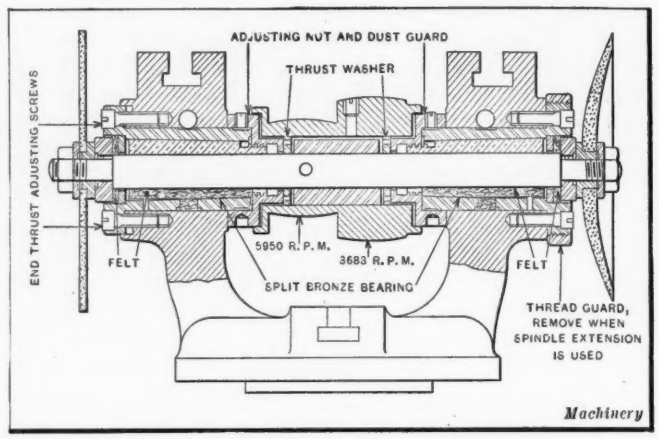


Fig. 2. Sectional View through Wheel-head

Dustproof tapered bronze bearings, which are adjustable for wear, insure accurate running of the wheel-spindle. The knee has broad vees, spaced 16 inches apart, and a box form of construction closed at top and bottom affords maximum resistance to all torsional and bending strains. Adjustable taper gibs compensate for wear on the column and insure long life for the machine. The saddle extension bearings completely protect the knee vees from dust in all positions. The table slide has one narrow dovetail guide and one flat way, and is provided with a full length adjustable taper gib. The table is supported in the middle and at both ends, and carries two scales reading in degrees and inches of taper per foot. A fine-pitch screw is used for setting over the table for handling taper work. A coarse table feed used especially for cutter grinding is operated from either side of the machine by a clutch lever, power being transmitted through a rack and pinion. Fine table feed is operated from either side of the machine by a handwheel through a screw and half-nuts. This screw is provided with a micrometer dial and can be used for bringing the work up to the wheel while the cross-feed is used for feeding the work across the grinding wheel. Provision is made to gear up the screw with the spindle of the index head when grinding spiral fluted hobs, the arrangement being similar to that used on the universal milling machine.

The principal dimensions of this machine are as follows: longitudinal movement, 17 inches; vertical movement, 10½ inches; cross movement, 9 inches; swing of universal head over table, 10 inches; swing of universal head right angle, 16 inches; size of table, 5¼ by 33¾ inches; width of T-slots, ⅝ inch; amount of swivel, 270 degrees; taper adjustment, 2 inches per foot; distance from center of spindle to table, 0 to 10½ inches; number of hand feed changes, 2; swing of work centers, 10 inches; maximum distance between centers, 20

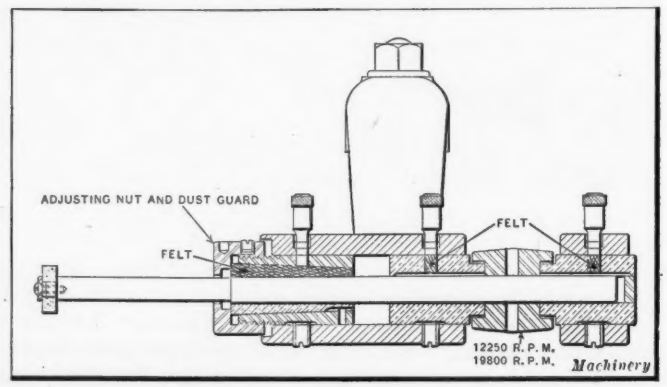


Fig. 3. Sectional View of Internal Grinding Attachment

inches; number of wheel speeds, 2; range of wheel speeds, 3683 to 5950 revolutions per minute; swivel of wheel-head, 180 degrees either way; capacity for handling face mills, up to 16 inches in diameter; capacity for handling form cutters, up to 7½ inches in diameter; capacity for handling saws on table, up to 48 inches in diameter; diameter of countershaft tight and loose pulleys, 6 inches; width of driving belt, 2½ inches; speed of countershaft, 850 revolutions per minute; and floor space occupied by machine, 49 by 68 inches.

WRIGHT CAGELESS ROLLER BEARING

Difficulty experienced with roller bearings having tapered rollers through the tendency of the wedge-like rollers to slip endwise was overcome by the late William Hamilton Wright through decreasing the cone angle of the races below a certain critical value. The value of the so-called "angle of repose" may only be determined by experiment and depends upon the nature of the surfaces in contact with each other. It still remained to determine a practical value for the angle of inclination of the axis of the roller in relation to the main axis about which general rotation takes place. These are principles involved in the construction of the full series cageless roller bearing manufactured by the Wright Roller Bearing Co., 1420 Chestnut St., Philadelphia, Pa.

The static elements are best considered by reference to Fig. 3, in which is shown a cross-section of a Wright bearing taken through a major or full diameter. It is necessary to determine whether or not the tapered conical roller when acted upon by the forces due to rotation of the bearing under load is subject to any tendency to slip endwise, and if so, whether the value of the resultant force is relatively large or negligible. Such a bearing in use is subjected to two principal load forces, which in the case of a wheel bearing are a dead weight carried upon a wheel, producing a radial load, and end thrust due to the resistance of the vehicle wheel to the side swinging of the body of the vehicle. A general case is shown in this illustration, wherein the direction of the radial load is indicated by the downward pointing arrow and the direction of a moderate thrust load is indicated by the upward pointing arrow, each of these lines representing not any solitary force acting from above due to downward pressure of the axle, or from below due to upward reaction of the hub of

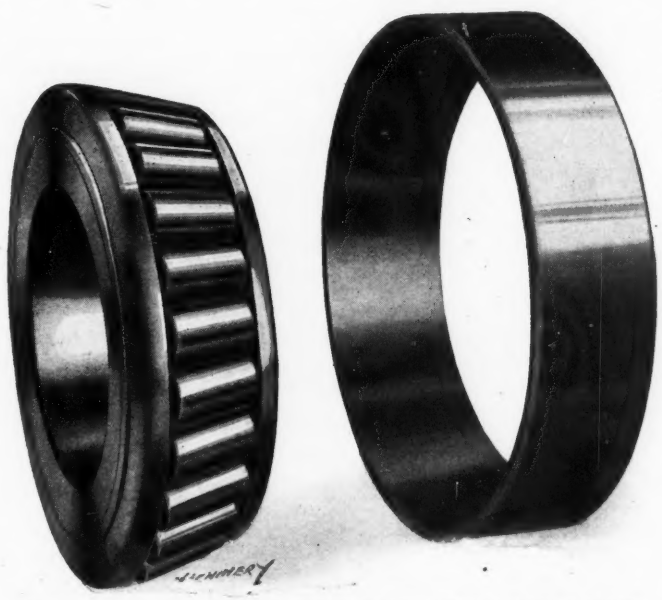


Fig. 1. Wright Cageless Roller Bearing, showing "Full Series" of Rollers

the wheel, but rather the resultant of all downward acting forces and all upward reacting forces on the conical roller.

If these two resultants take directions such that a line passing through the intersection of the two lines forms an angle of less than 180 degrees on the side toward the apex of the conical roller, they are bound to have a resultant T which is a thrust tending to produce a slipping of the roller in the direction indicated. Whether slipping will occur depends upon whether or not the value of force T exceeds the value of the opposing friction due to pressure upon the roller in its position between the two raceways. The value of the opposing friction is relatively much greater than is commonly supposed, and in a bearing of this kind under load no one of the several rollers in the load zone can be driven out of position except by a relatively great force.

Fig. 2. Wright Cageless Roller Bearing assembled

In a properly designed roller bearing, the necessary force required to produce end slip is never present unless the direct horizontal side thrust has a value greater than 50 per cent of the direct radial load. However, in order to insure positive security, the rollers ride about the inner raceway between flanges which limit the movement of any roller in the direction of its own axis. In the general case, if the angle formed by the resultant of the lines representing the two forces as shown in the diagram is less than 180 degrees on the side corresponding to the bases of the cones, the final resultant T will have a negative value, or will act in a manner tending to produce end slip of the roller in the direction of its apex, or as of a driven wedge. In everyday operation the actual case lies between the two conditions illustrated.

A most important consideration of design is now to be noted, namely, that the width of tread between the shoulders is greater than the length of tread of the roll. Herein lies the condition for the perfect freedom of rotation of this type of bearing. It should be obvious to the average reader that the tendency of the roller shown in the diagram is to react under pressure against the inner tread by sliding to the right, while its tendency to react against pressure due to the outer tread is by sliding to the left. The manner in which these two tendencies counteract each other is best considered if the bearing is now treated as respecting kinetic conditions.

When rotating, it is found that the conical rollers, under the play of forces whose resultants never take the same direction very long at a time, tend to "weave" slightly from side to side in their position between the treads, and if a moderate amount of clearance is allowed in limited width of inner tread, freedom of the rollers is assured. Even though they may, for an instant, under an extremely heavy side thrust, move endwise far enough to make contact with the opposing shoulder in one direction, they instantly and automatically free themselves as they pass out of the load zone of the bearing into the upper part of the bearing. An advantage of the "free-race" bearing is

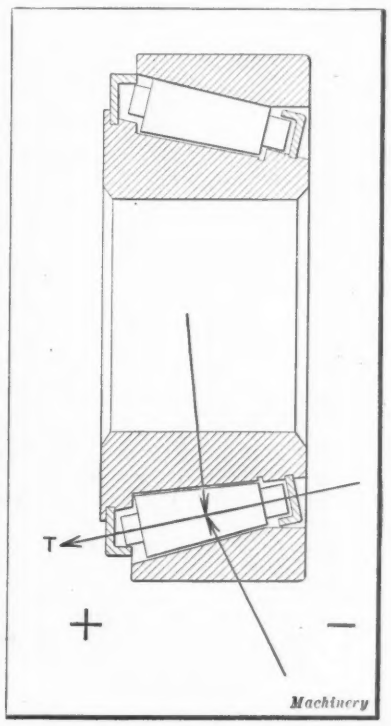


Fig. 3. Cross-section of Wright Bearing

here demonstrated, namely, that although a severe thrust may occasion conditions wherein friction between rollers and the opposing shoulder tends to produce temporary misalignment of the rollers, if they are left free they will right themselves.

Two remaining points of interest may be touched upon, first as to how alignment is maintained, and second as to what the friction is between adjacent rollers, the surfaces of which are moving in opposite directions. If anyone will take a lead pencil and place it inside the outer ring, commonly known as the "cup" of a taper roller bearing, it will readily be perceived that in any other position than with its axis in the proper alignment there are forces tending always to produce proper alignment due to the geometrical characteristics of the conical interior surface. Upon the point regarding opposite rotation of adjacent rollers, it should be noted that a total clearance approximating about one-third the diameter of a roller is provided for the entire "full-series" in the raceway. Contact could not exist between all rollers unless all the clearance is maintained at one point.

AJAX FORGING MACHINE

The first seven-inch forging machine built by the Ajax Mfg. Co., Cleveland, Ohio, which was placed on the market in 1911, was similar in appearance and construction to the present machine, except that it was much lighter and had a more limited capacity. Since that time several seven-inch machines have been built, notably special machines for the production of large annular rings, bevel gears, etc. These special machines are different from the standard only in that they have a single toggle operating the moving die in place of the double toggle used in standard machines. These machines have a narrower die slide, and consequently they are about ten inches shorter than the standard type of machine.

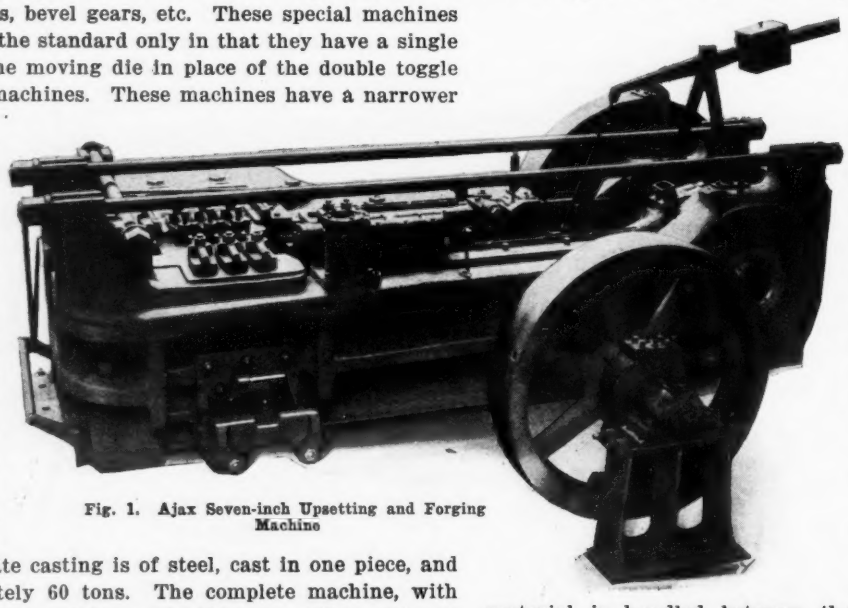


Fig. 1. Ajax Seven-inch Upsetting and Forging Machine

The accompanying illustrations show the new seven-inch Ajax upsetting and forging machine, which is said to be the largest and most powerful forging machine built. The bed plate casting is of steel, cast in one piece, and weighs approximately 60 tons. The complete machine, with its regular equipment, weighs nearly 100 tons. When stripped of all accessory equipment, gear, flywheel and other parts, which can be removed without entirely dismantling the machine, the weight just comes within the capacity of a 150,000-pound ordnance gun truck car. The length of the bed plate is 21 feet, and the width, 9 feet, 6 inches, which is practically the limit of width which may be shipped over railroad lines.

This new machine is built along the lines of the standard

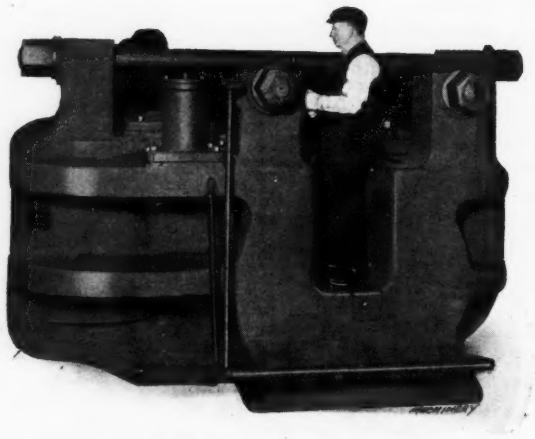


Fig. 3. End View of Ajax Forging Machine

Ajax upsetting and forging machines of all sizes. The crankshaft housings are continuous, being bored large enough to take the throw of the crank. The bronze-bushed bearings are pressed into the bed from each side, forming solid bearings for the crankshaft. The momentum of the crankshaft and pitman are utilized in this machine, as the clutch mechanism is located between the main slide and the pitman. As this clutch can only pick up the main slide and start it in motion at the end of the stroke, the action is very easy, and a minimum of power is used in starting the operating parts of the machine. Side motion of the die is operated through a set of knuckles from the main slide in such a way that the dies are closed when the heading tool is about half way forward, and remain closed until the heading tool comes back to the same point. This insures the heading tool being free from the forging before the grip is released. Liners may be used in the die to provide for the use of smaller blocks when light work is being done on the machine.

The production of forgings on this machine is determined largely by the efficiency with which the material is handled between the furnace and the forging machine, and also by the heating capacity of the furnace. One automobile company has produced 540 large bevel gears in eight hours, the method used being to upset on the end of a solid bar, then push the bar back, and leave the ring in the dies. This produces forgings of this type without waste of material, except for a few inches at the end of the bar that cannot be gripped in the dies.

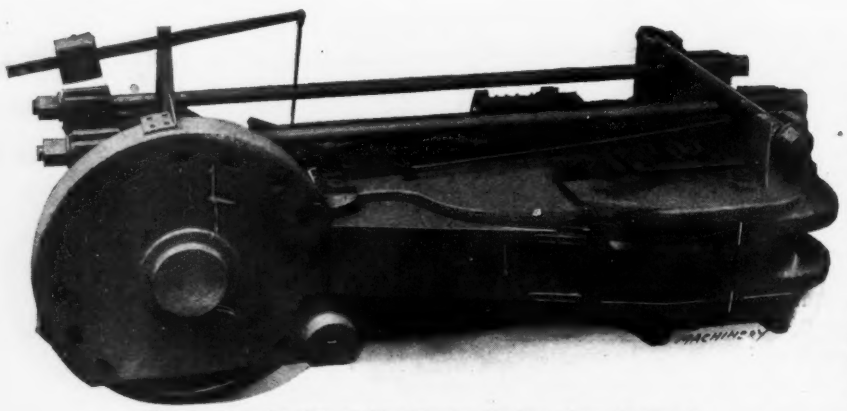


Fig. 2. Opposite Side of Ajax Forging Machine shown in Fig. 1

AUTOMATIC TAPPING AND DRILLING MACHINE

W. H. Simmons & Co., 208-212 Lawrence St., Cincinnati, Ohio, are now building the "Cinti" automatic tapping and drilling machine shown in the accompanying illustrations. The clutch and reversing mechanism of this machine can be set to run the tap to any desired depth and reverse automatically; after the tap clears the work, the spindle also stops automatically. The clutch, as well as other contact points, is made of hardened steel to afford ample durability. A lead for any desired pitch of thread is used on the spindle, and 16, 18, 20 and 24 thread leads are standard equipment. The

belt tightening device is operated by a knob on the right side of the column near the base, and the belts can be adjusted to any desired tension. Bronze bearings are furnished throughout this machine, and the lower pulleys are provided with bronze bushings.

The principal dimensions of the machine are as follows: capacity for drilling or tapping to the center of a 12-inch circle; maximum distance from spindle to table, 10½ inches; vertical adjustment of spindle, 3¼ inches; vertical adjustment of table, 5 inches; diameter of spindle in sleeve, 13/16 inch; diameter of table, 10 inches; diameter of cone pulley steps, 3½ to 7 inches; width of driving belt, 1½ inch; size of tight and loose pulleys, 7 by 1¾ inch; tapping capacity in cast iron, up to ⅜ inch in diameter; drilling capacity in cast iron, up to ½ inch in diameter; speed of tight and loose pulleys, 300 revolutions per minute; and available spindle speeds, 150, 250, 390 and 600 revolutions per minute.

Fig. 1. "Cinti" Automatic Tapping and Drilling Machine built by W. H. Simmons & Co.

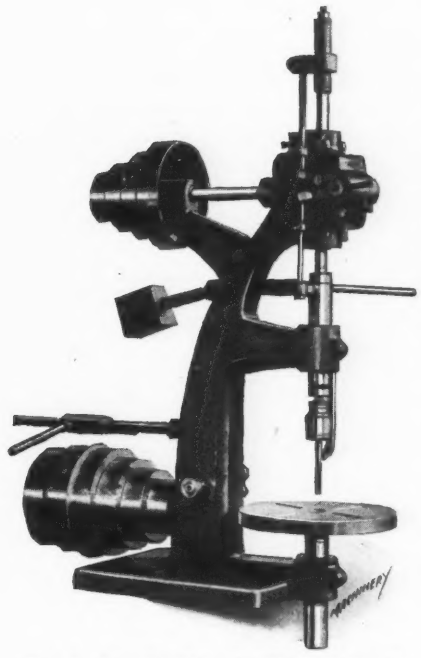


Fig. 2. Opposite Side of "Cinti" Automatic Tapping and Drilling Machine shown in Fig. 1

ing the spindle speeds. The lower pulley near the bottom of the column, the pulley on the end of the spindle and the upper pulley on the swinging arm are made interchangeable, and in combination with the two-speed gear-box and transposing gears, twelve spindle speeds are obtainable, having a range of from approximately 150 to 1035 revolutions per minute.

Reference to Fig. 2 will show that the large sprocket wheel is keyed to the hollow shaft, which is the main driving shaft. The quill gear is also keyed to this shaft and drives the sliding gear on shaft *A*. Gears *B* and *C* are transposing gears, and either one can be used on shaft *D*, which runs in bronze bearings at each end of the hollow shaft. The hollow shaft, to which the large sprocket wheel is keyed, and pulley shaft *D* both run in the same direction. The chains and sprockets are entirely covered, which will be apparent by referring to the view of the machine shown in Fig. 1.

SUPERIOR MOTOR-DRIVEN MILLING MACHINE

The Superior Machine & Engineering Co., 51-53 Fort St., Detroit, Mich., has recently applied motor drive to its hand milling machine. The machine is shown in Fig. 1, and Fig. 2 illustrates a section through the speed gear-box with a sliding gear and transposing gears on the end of the shafts for vary-

Fig. 1. Superior Hand Milling Machine equipped with Motor Drive

SCHOENERT REAMERS AND TAPS

Carl Schoenert & Sons, Inc., 631-633 S. 20th St., Newark, N. J., is now manufacturing the reamers and taps here shown. Fig. 1 shows a number of sizes of the reamer for which the following advantages are claimed: First, a perfectly smooth

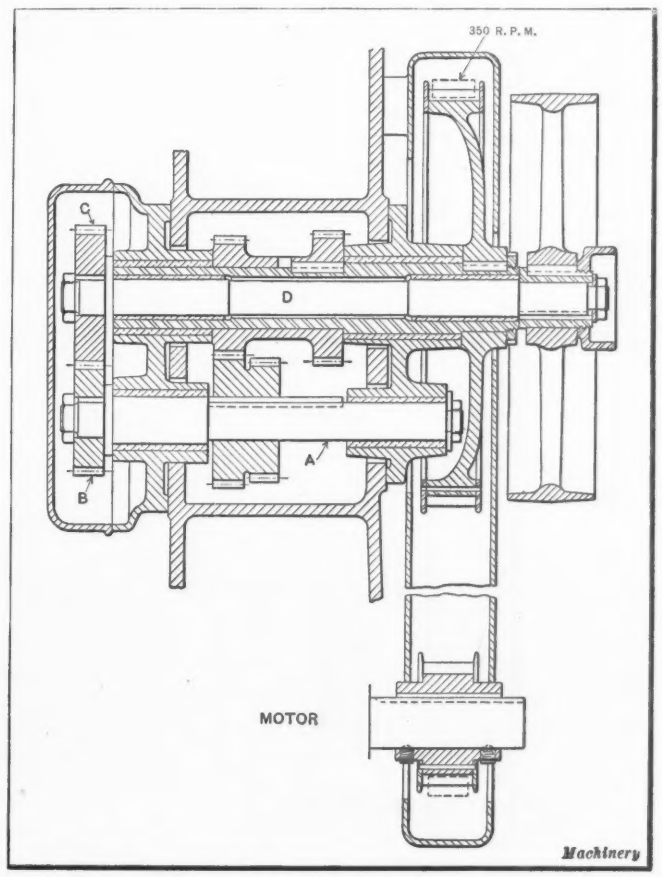


Fig. 2. Section through Speed Gear-box for varying Spindle Speeds

and exactly cylindrical hole is reamed, it being impossible for these tools to leave any chatter marks, as they are guided by the full length of the tool at the opposite side from the cutting edge; after being reamed, the hole appears perfectly polished. Second, the reamer can be easily sharpened on an ordinary grinding wheel without requiring the use of a special attachment. The cutting edge is simply held against the grinding wheel and ground to the shape of the wheel, which is said to make a good cutting edge. Schoenert reamers are made with straight and taper shanks and in various sizes. The central hole in the reamer facilitates lubrication and provides chip room, as the chips tend to crowd into the hole in the tool, where they give no trouble.

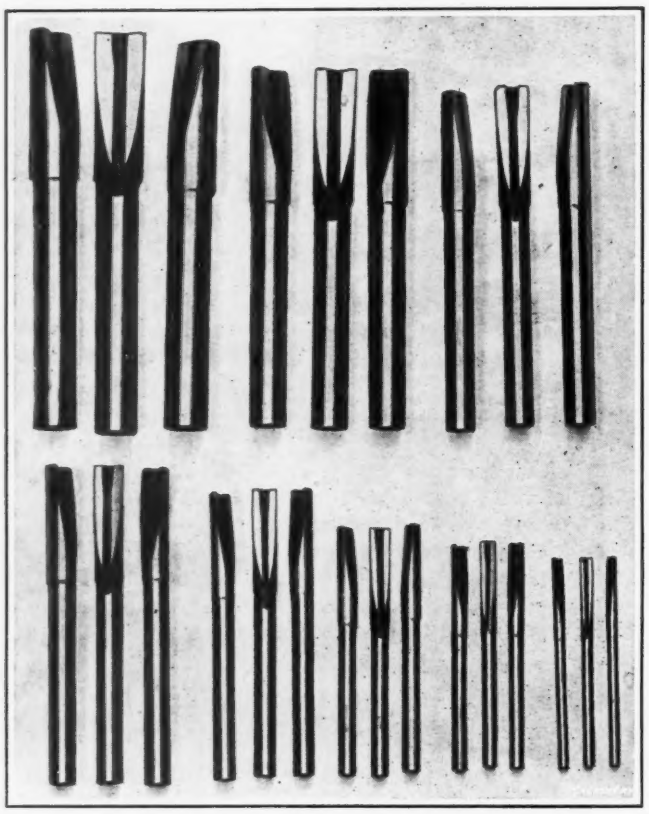


Fig. 1. A Number of Sizes of Reamers made by Carl Schoenert & Sons, Inc.

This reamer usually makes a hole of exactly the size of the tool, cutting as close as 0.0001 inch to size. It cuts the material the same as a lathe tool will cut it, but never digs in. The chips have the same shape and appearance as those produced from a lathe tool, and the cutting clearance is more than on any standard reamer. The reamer may be used either right or left, as there are cutting edges on both sides. If the right-hand side is worn off, it may be used left-handed. However, the grinding takes only a little time, and so there is no occasion for not keeping the reamer properly sharpened. Fig. 2 shows a close view of two of the reamers and some of the chips produced by them.

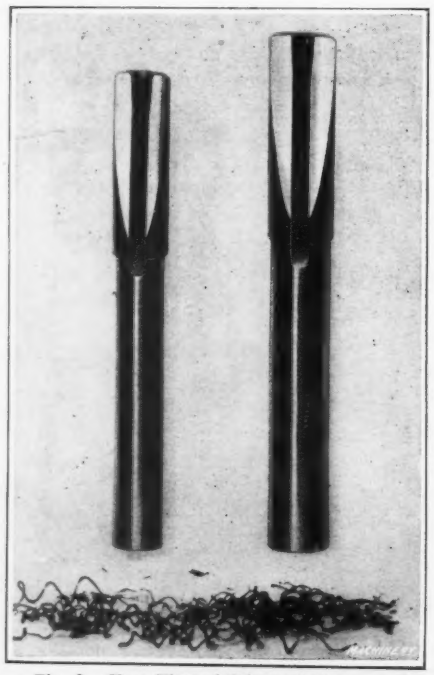


Fig. 2. Close View of Schoenert Reamers and Chips made by them

The same general form of construction is employed in the Schoenert taps, three of which are illustrated in Fig. 3. They have much more clearance than the ordinary tap and cut the chips out the same as the reamer does. These taps are said to be especially valuable for use where lubrication is important. The hole through the center of the tap gives the lubricant a chance to flow freely to the work. Owing to the spiral on the tap, the cutting edges also work better than would the straight cutting edge on the regular tap.

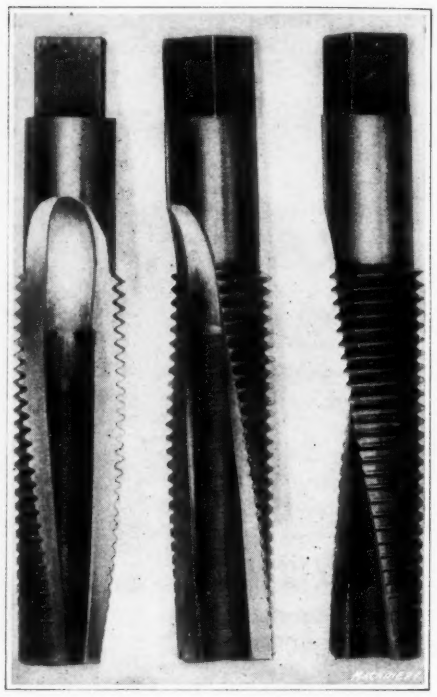


Fig. 3. Schoenert Taps made on Same Principle as Reamers shown in Figs. 1 and 2

G. E. DYNAMIC BRAKING CONTROL FOR CRANE HOISTS

The General Electric Co., Schenectady, N. Y., has recently brought out an automatic device, which can be added to its standard Type B drum controller and thus make a serviceable semi-magnetic dynamic braking control for crane hoist service. The additional equipment consists of: a panel for wall mounting, which contains a direct-current contactor and current limit relay; and an extra resistance, which is inserted in the circuit during the acceleration and deceleration period. A dynamic braking, manually operated, drum type controller is more severe on the commutator of a direct-current series motor than is a plain reversing manual controller, because when lowering, the motor is connected similarly to a shunt-wound motor and does not have the inherent protection of the series field. In many installations, where the service is severe, a semi-magnetic equipment will materi-

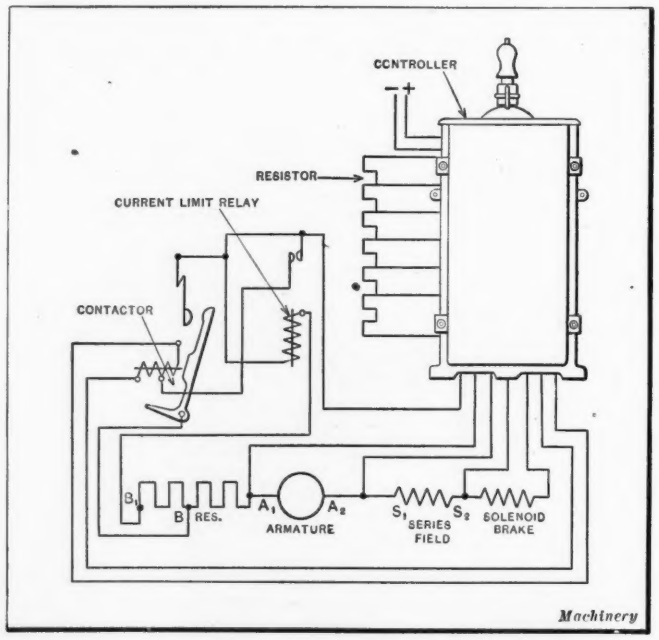


Diagram showing Principle of G. E. Dynamic Braking Control for Crane Hoists

ally assist commutation. This equipment is useful also where the service is not quite severe enough to justify the expense of a full magnetic equipment.

The connections, when used with the dynamic braking controller, are shown in the accompanying diagram. The extra resistance BB_1 is to be added to the resistance regularly furnished with this controller. With the new arrangement this block of resistance would be so high that it would be impossible to damage the motor, no matter how quickly the controller was thrown on and off. The contactor and relay simply insert and cut out this resistance when accelerating and decelerating in such a manner as to give practically the same speed characteristics on the motor as would be obtained with a standard controller and at the same time prevent abusive currents. This device protects the commutator from severe arcing, and protects the controller fingers and segments from severe burning. It enables the motor to run at a higher lowering speed for a given severity and condition of service, provided extra resistors are used to weaken the motor field.

NEW MACHINERY AND TOOLS NOTES

Magnetic Chuck Fixtures: Lawson & Co., 90 West St., New York City. Three magnetic chuck fixtures for holding small or irregular shaped pieces on an ordinary magnetic chuck. These comprise a set of parallels, a V-block, and a protractor block with a V-shaped top.

Radius Gage: Moss-Ochs Co., 3387 E. 116th St., Cleveland, Ohio. A universal radius gage for determining the accuracy of concave or convex surfaces of tools and dies from ⅛ to 1 inch radius. This gage does not have separate leaves for concave and convex surfaces, but has a convex surface on one side and a concave surface on the other.

Radial Drilling Machine: Canedy-Otto Mfg. Co., Chicago Heights, Ill. A radial drilling machine built in two models, one of which has power feed and the other hand feed. Both of these models are built with either a 2½- or 3½-foot arm. Four changes of speed are provided by four-step cone pulleys, and the spindle and feed drives are operated through bevel gears at the top of the column.

Angle-plates: Simplex Tool Co., Woonsocket, R. I. Angle-plates intended for the use of toolmakers. These plates can be used on a bench lathe faceplate, grinder, on the bench or in other ways. Both the inside and outside faces of the plate are ground, and tapped holes are provided in one side and plain holes in the other side of the angle. The plates are made of hardened steel and ground all over.

Thread Milling Fixture for Shells: Hall Gas Engine Co., Inc., Bridesburg, Philadelphia, Pa. A fixture for threading shrapnel and high-explosive shells, which is designed for use on a lathe or milling machine. This attachment is adapted for producing either internal or external threads in brass, aluminum, steel and other metals. The attachment can also be employed for threading many other classes of work besides shells.

Tool-room Lathe: Cleveland Machinery & Supply Co., Cleveland, Ohio. A 12-inch tool-room lathe, the design of which includes the following features: a geared headstock, a gear-box arranged for cutting either U. S. standard or metric threads without the use of translating gears, and a relieving attachment for angular, straight or taper relieving operations. The bed is made unusually heavy to adapt the machine for heavy work.

Disk Grinders: Guy G. Townsend, Winchendon, Mass. A line of heavy-duty disk grinders which replaces the line of lighter machines of similar design formerly manufactured by this machine builder. The tables are constructed with adjustable gibs, and the head swing-shaft bearings are adjustable. Abrasive wheels are mounted in steel disks, and hoods serve both for safety and for the additional purpose of carrying away abrasive dust.

Crank-case Reamer: Taft-Peirce Mfg. Co., Woonsocket, R. I. A tool known as the "Mantell" adjustable reamer. A parallel movement of the reamer blades is secured by means of inclined planes or wedges which fit into the slot at each end. The blades are set in the reamer at opposite angles, two in one direction and four in the other, but so arranged that the advantage of uneven spacing is obtained. It is possible to caliper any pair of blades at any point.

Drill, Tool and Toolpost Grinder: Universal Electric Co., Inc., 5 Oliver St., Newark, N. J. A machine known as a universal drill, tool and toolpost grinder, which is driven by a ¼-horsepower motor. This machine may be supported on a stand for use as a tool or drill grinder, or it may be lifted from the stand and supported in the toolpost by means of a suitable shank. The stand is equipped with a table rest for grinding tools and a V-rest for sharpening drills. The motor is supplied for either direct or alternating currents.

Multiple Drill Head: Nelson-Blanck Mfg. Co., Detroit, Mich. A line of adjustable multiple-spindle drill heads. An adapter at the top of the head is separable, so that a change may be quickly made. The driving shank is square and slides in a square hole in the driving gear, thus allowing different sized tapers to be used without taking apart the entire head. A ball thrust bearing is provided for the driving shank, and the driving gear runs in S.K.F. ball bearings. These heads are built in four styles to take drills with No. 0 straight and Nos. 1, 2 and 3 Morse taper shanks.

Continuous Milling Attachment: Mann Corporation, Kankakee, Ill. An attachment known as the "Manco" continuous miller, which is self-contained and can be mounted on any drilling machine of suitable size. Drive is transmitted through a universal joint. This outfit will handle a variety of work usually done on plain or hand milling machines. The work-table is 13¼ inches in diameter, has both hand and power feed, and carries a series of pieces; as it rotates, it carries the work to a milling cutter mounted on a 1¼-inch arbor supported by a steel column.

Dynamic Balancing Machine: Carlson-Wenstrom Co., Richmond St. and Erie Ave., Philadelphia, Pa. A dynamic balancing machine of similar design to that formerly built by the Dynamic Balancing Machine Co. of Philadelphia. Rights to manufacture this machine under the Akimoff patents have been acquired by the Carlson-Wenstrom Co., and certain changes have been made in the design of the machine. The most important of these is the greater convenience of operation through provision of handwheels for making all adjustments while the machine is running. This is claimed to be the means of doubling the capacity.

Precision Lathe and Grinder: Ideal Machine & Tool Co., 128 Opera Place, Cincinnati, Ohio. A combination precision lathe and grinder, which swings 7 inches and is made with beds of various lengths, the shortest of which takes work up to 12 inches between centers. A compound slide-rest is used which will give a longitudinal feed of 3 inches at one setting, and the cross-feed also has a maximum movement of 3 inches. A 4- by 6-inch table with T-slots, which is adjustable to any angle, is mounted on a bracket at the rear and has a vertical movement of 4½ inches. This table is used for holding work while grinding.

Drilling Machine: Colburn Machine Tool Co., Franklin, Pa. A heavy-duty drilling machine that is constructed on the unit principle. The machines are provided with one, two, three or four spindles. The drive is through a constant-speed belt to the main driving shaft. Two mechanical speed changes are provided, which are operated in conjunction with an arrangement for changing gears which makes it possible to obtain forty different speeds ranging from 74 to 508 revolutions per minute. Thirty-six changes of feed are available, covering a range of from 0.005 to 0.153 inch per revolution of the spindle. These changes are obtained by means of a worm feed handwheel. An automatic tripping mechanism is furnished to disengage the feed at any desired point.

Back-geared Lathe: Giddings & Lewis Mfg. Co., Fond du Lac, Wis. An 18-inch double back-geared lathe, driven by a three-step cone pulley. The bed of this machine has a large V-bearing at the front and a flat surface at the rear for the carriage, while there is a second smaller vee for lining up the headstock and tailstock. Back-gear ratios are 9 to 1 and 3 to 1. The spindle is made of a carbon steel forging, which is ground to size, and the spindle runs in self-oiling phosphor-bronze bearings. The lead-screw is made of carbon steel with a four-pitch Acme thread. Eight changes of feed are furnished by the standard gear-box, while a special change-gear box, which is interchangeable with the standard box, gives forty changes. Screws with metric pitches may be cut by using a pair of gears running on idlers on the quadrant stand.

Disk Grinder: Charles R. Carpenter Machine Co., Robbinsdale, Minn. This machine is known as a disk flat surface grinder, and the following are noteworthy features of its design: Angular adjustment of the universal table is controlled by means of a clamping handle located immediately below the table. This arrangement works in connection with a graduated table top and protractor blade to provide for instantaneously placing the table in position for accurately grinding plain or compound angles. Clamping handles are provided for the table arms, allowing them to be quickly clamped or released to oscillate in the usual manner. The table two-way thrust collar is enclosed within the table arm, thus making both bearings absolutely dustproof. At the disk ends of the table arm bearings dust shields are provided to prevent the table studs from becoming charged with grit. The machine arbors are turned and ground, and supported in two split bronze bearings, which are adjustable for wear. This machine is equipped with two 18-inch disks, and weighs 1700 pounds.

ACCURACY TESTS IN MANUFACTURING THE TILTED TURRET

BY J. W. BARBOUR[1]

The Wood Turret Machine Co., Brazil, Ind., in assembling its tilted turret lathe, employs several interesting methods and tests to insure the accurate alignment of the turret holes and the spindle. After the machine bed is thoroughly seasoned and finish-planed, it is sent to the hand scraping department, where the ways are scraped and spotted to a heavy surface plate; the bed is then set up on a specially equipped boring mill and bored for the spindle bearings. The bearings are next placed in position, after which the machine is returned to the erection department, where the bearings are scraped to the spindle. The initial test is then made to determine the alignment of the spindle with the ways. A telescoping fixture is used for this purpose and readings are made at all positions on the ways, both for lateral and for horizontal alignment.

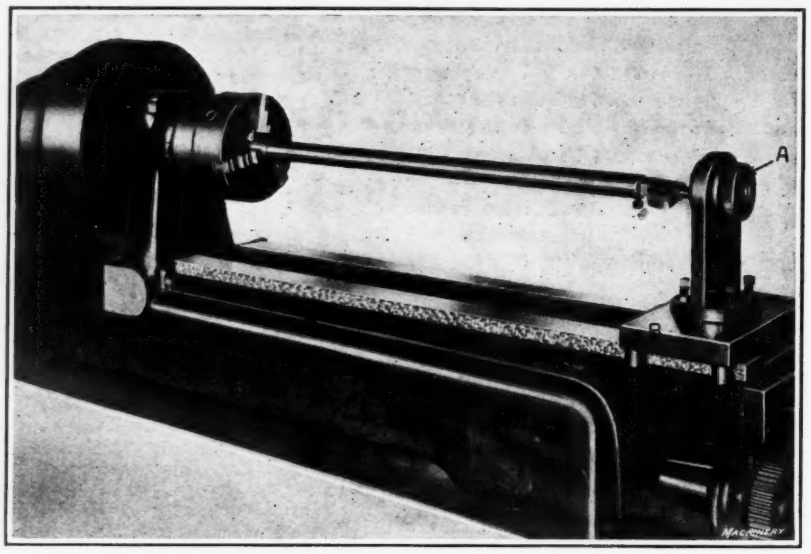


Fig. 1. Testing Alignment of Spindle with Ways

In Fig. 1 is shown the final test for alignment of the spindle with the ways. The bar holding the indicator is slipped back through the spindle until the indicator comes up near the chuck, and the fixture *B* is moved along the ways until the indicator enters the hole of the hardened and ground bushing *A*. Then, while the spindle is revolving, the bushing *A* is adjusted so that the indicator points to zero during the complete revolution of the spindle. The fixture *B* is then moved to the end of the ways, as shown, the adjustment of bushing *A* remaining unchanged. After the bar that holds the indicator is moved through the spindle until the end of the indicator enters bushing *A*, the spindle is revolved, and if the indicator points to zero for a complete revolution, as it did at the chuck, the alignment of the spindle with the ways is perfect. It requires from three to four hours to obtain a satisfactory bearing.

The saddle slide and turret head are assembled as a complete unit. After all the surfaces on these parts have been scraped to heavy surface plates, this unit is placed in position on the ways of the bed, and a crank fixture, which moves the slide the full length of its travel, is attached to the rear end of the slide, as shown in Fig. 4. This fixture is driven from the lineshaft, and indexes the turret at the rate of forty complete strokes per minute. As it is run for a period of six hours, the entire indexing mechanism is limbered up and tendency to spring in any of the surfaces is overcome. Before this operation, the slide and saddle are hand-scraped to each other, so that moving the slide and the saddle and revolving the head mechanically brings the slide to a good seated bearing and also causes the locking pin to seat itself perfectly in the locking bushing before the holes in the turret head are finished. Any defects will thus be discovered before the machine is completed.

The turret head is next bored to within 0.010 inch of size from its own spindle; then the tooling surfaces are machined by the special star-feed facing fixture shown in Fig. 2, which is also mounted on the spindle. This tool machines each face of the turret head at right angles with the hole

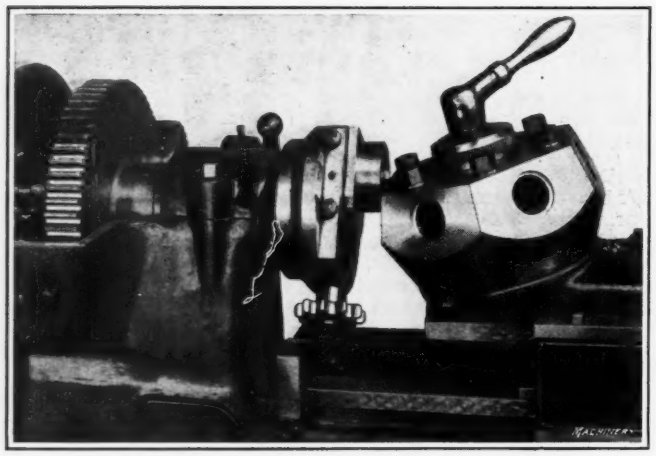


Fig. 2. Special Tool facing Turret True with Spindle

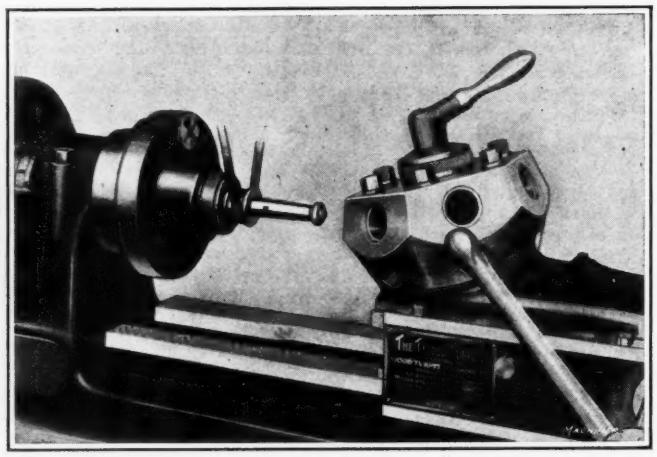


Fig. 3. Grinding Turret Holes in Perfect Alignment with Spindle

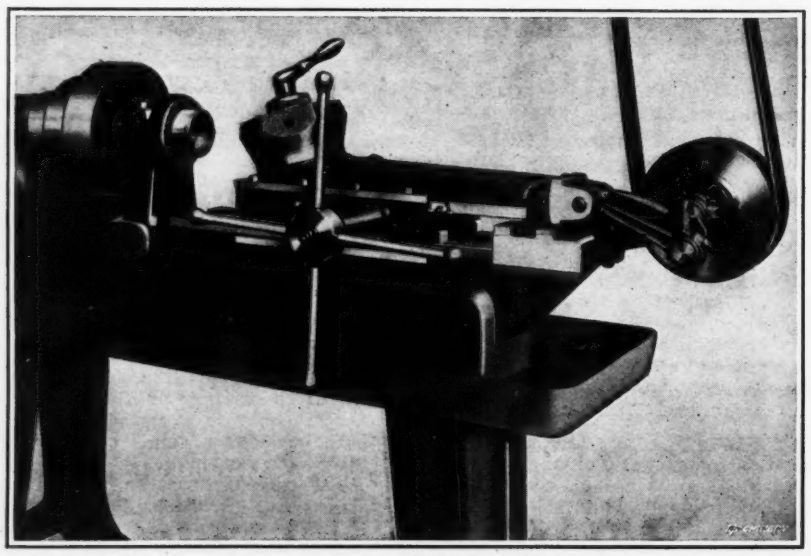


Fig. 4. Turret Head attached to Fixture that revolves Head and moves Slide and Saddle

[1] Sales Engineer, Wood Turret Machine Co., Brazil, Ind.

and true with the spindle. This insures perfect alignment with any tools that may be bolted to the head.

The next operation, which is probably the most interesting, is that of grinding the turret holes by means of the specially designed grinder shown in Fig. 3. A motor is mounted over the front bearing, on a stand that is clamped to the ways, and the grinding fixture is inserted in the end of the spindle. Each turret lathe has the holes in the turret head ground from its own spindle, which insures perfect alignment of the holes and the spindle, and avoids trouble from non-alignment commonly encountered when the holes are reamed. All holes are ground the same size with this attachment. The adjustment of the grinder is very sensitive, and it can be easily set to the smallest fraction of an inch. This fixture is of the planetary type and operates on the same principle as the Heald grinder; it is adjustable for different sizes of holes, and duplicate grinding can be done within very close limits. This permits of absolute accuracy in sizing the turret holes and eliminates the bell-mouth tendency that often follows the use of boring-bars and reamers.

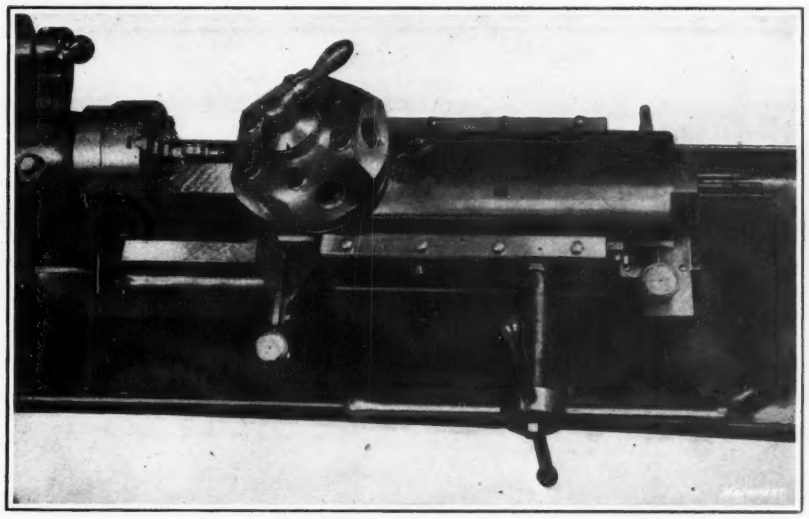


Fig. 5. Making Final Alignment Tests

Following this operation, the machine is ready for the final inspection. The head, slide and saddle are taken down and thoroughly cleaned to remove foreign substance. They are then reassembled and an indicator is placed at each end of the slide, to test both the vertical and the horizontal alignment; another indicator is held in the chuck of the machine to test the holes in the head, as shown in Fig. 5. Readings are then taken over the full length of travel of the slide on the tooling face of the turret, in the front and back of the turret holes, and on a plug extending six inches out of the turret hole. The work is held to within 0.001 inch limits. If there is any inaccuracy, it is found by this inspection before the machine is shipped.

Allowance is made for inaccuracies that may develop after extended use of the tilted turret. The turret slide is furnished with taper gibs, which are fitted the whole length of the saddle on each side and provide a means of adjusting the slide sideways. The saddle is gibbed to the outer edges of the bed by flat gibs throughout its entire length, and it has a supplementary taper base, by means of which the turret holes can be adjusted to maintain their exact height in relation to the center of the spindle.

* * *

U. S. ARMY MOTORIZED FIELD BATTERY

The United States Army has developed what is believed to be the first completely motorized field battery of medium caliber guns in the world. The work has been in charge of Major Lucian B. Moody, who has been assisted by the tractor standards committee of the Society of Automobile Engineers.

European armies have reduced greatly the number of horses in artillery use, but it has not been possible to eliminate them in hauling certain of the smaller and medium types of ordnance because of the lack of a proper tractor combination of speed and power. The big creeping type tractors capable of handling the heaviest guns have been unable to make the occasional bursts of speed necessary for getting the light field guns into position and using the minimum of space that conditions on the firing line frequently make vital.

The new creeping, or self-track-laying, type of small or medium size tractor developed by the American Army is built without the steering arrangement in front, and while possessing relatively as much power as the type now used in Europe, is capable of turning within its own length by simply reversing or stopping one of the creeper drivers while the other side continues to move ahead. The development in this type of tractors powerful enough to haul the heaviest guns will make them available for making the sharp turns and corners and fitting into the inconvenient spaces for which horses have so far had to be used at the front. The experiments have proceeded far enough to justify plans for the successive motorization of all American artillery units except the smallest calibers required to move at very high speed over bad ground.

From a scientific and military standpoint, the tractor is much more efficient than the horse. It lasts longer, is capable of performing more work in a day, and costs less for repairs and fuel than the expense of upkeep of the horse. A tractor can, if necessary, be used 24 hours a day, while the horse has to stop for rest, sleep and feeding, and can seldom be worked more than ten or twelve hours a day at the most.—*The Official Bulletin.*

* * *

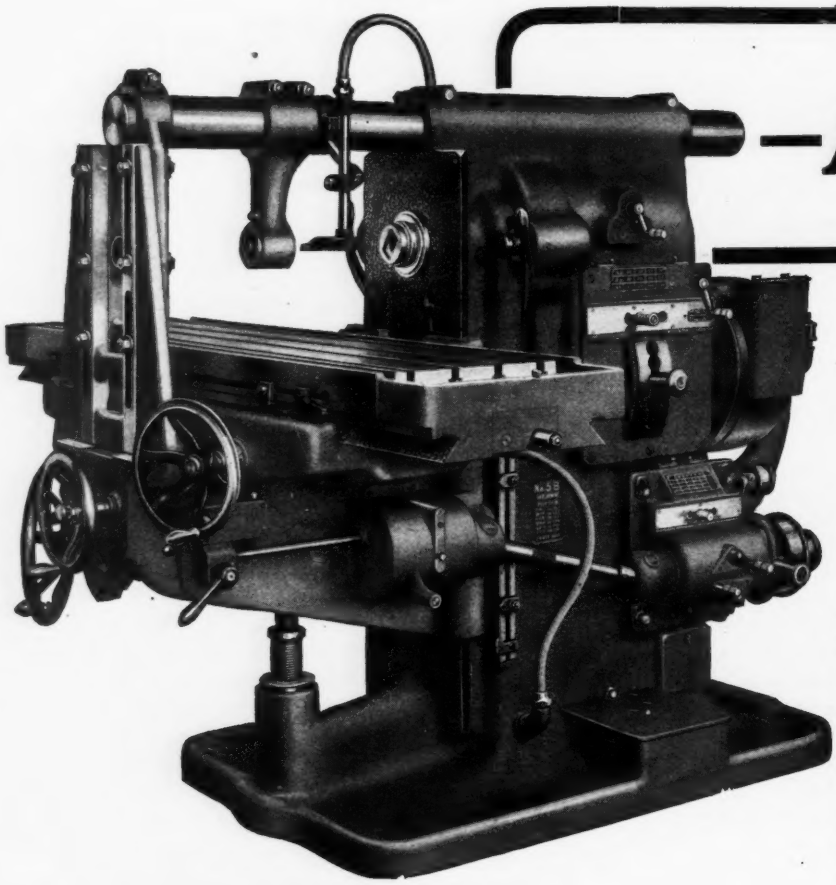
A MACHINIST WITH STEEL HANDS

For some time the nations at war have sought artificial arms and hands that will enable cripples to resume their former occupations with little disadvantage. The need of effective devices of this sort is felt not only by war cripples, but by the many who have lost their members in industrial pursuits. Andrew Gawley, an employe of the Fisher Motor Co., Orillia, Ontario, has steel hands to replace the hands he lost some years ago through contact with a circular saw, which were made to his own design. These are said to be very effective indeed. Mr. Gawley is now employed in the tool crib of the Fisher Motor Co., and he can pick up pieces of varying sizes and weights with confidence and ease. He keeps track of the printed forms of all material that goes out and attends to the general duties of his position. Before entering the tool crib, Mr. Gawley worked on a drilling machine. His steel hands are so strong that when drilling shell adapters weighing forty-five pounds each, he was able to lift an adapter on and off the machine table with one hand, being the only man who could handle the pieces in this way. Yet the steel hands are so well under control that he can write a legible hand, pick up a fragile cup by the handle, dress himself, light a lamp, and do many other things that would seem impossible of accomplishment by an artificial member.

* * *

MARINE ENGINEERS NEEDED

The United States Shipping Board is seeking the name and address of every man in the United States who can qualify, with or without special training, for a position as an engineer officer on an American merchant ship. The merchant marine will need within eighteen months 5000 additional engineers in all grades. To start in training those not yet qualified to secure United States inspection papers, the government will open on July 2 a chain of free schools in marine engineering, at some of the best known technical colleges in the country, for which marine engineers of all grades, oilers and water tenders, also stationary engineers, are eligible. The duration of term is one month. After passing examinations of steamboat inspection service, students will have opportunity for further training under service conditions until wanted on ships of the new merchant marine.



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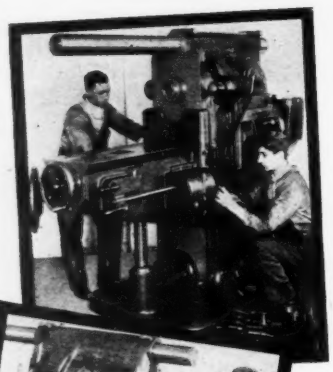
It isn't just because they have a massive column, a rigid knee and a wide bearing table or because the overhanging arm is large and rigidly supported, it is because every part is rugged, well proportioned and in perfect balance with every other part that they give year-in-and-year-out efficient service on the heaviest and hardest milling that comes within the province of a column and knee type machine.

1



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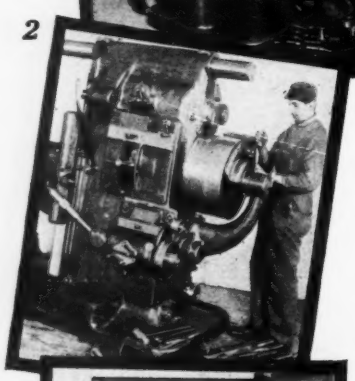

3

BROWN & SHARPE

Heavy Service

MILLING MACHINES

The Photographs at the Left Illustrate:

1. The rigid design of the knee with its ample vertical depth and long bearing surfaces for both column and saddle. Note the liberal extension at top of knee—the point of greatest stress.
2. The large proportioned driving pulley with extra wide face—one of the chief elements that provide for a powerful drive.
3. The wide table bearing surfaces of the saddle—long in proportion to length of the table to fully resist the severe stresses when table is heavily loaded and at the end of its traverse.

May we tell you of the many other details of rugged construction and the many features of these machines? Send for literature.

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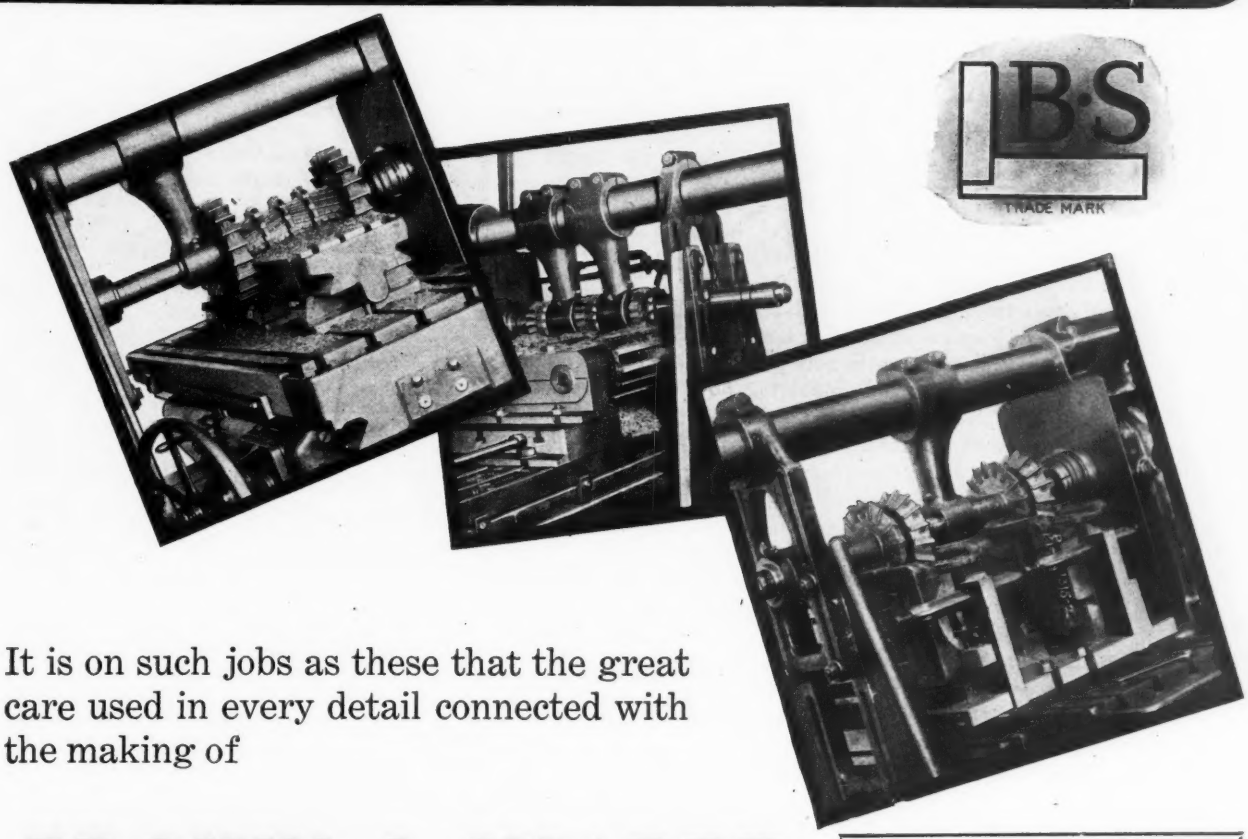
Bit as Sturdy as They Look



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MACHINERY'S MOTION PICTURE ON ITS TRAVELS

The mechanical world is evincing great interest in MACHINERY'S motion picture, which shows in detail every operation in the machining of a 9.2-inch high-explosive British howitzer shell. The picture was first shown at the joint session of the American Society of Mechanical Engineers and the National Machine Tool Builders' Association, Hotel Sinton, Cincinnati, Ohio, May 22, and was again shown in the same place May 24 to a large audience comprising mechanical executives of Cincinnati.

Requests for exhibitions of the film have come in from all over the country, and it will be shown in the chief industrial centers as soon as arrangements can be made. Wherever it has been shown, the audiences, being chiefly men familiar with mechanical practice, have been greatly interested and have plied with questions Chester L. Lucas, associate editor of MACHINERY, who presents the picture and gives a preliminary lecture on the different types of shells used by the warring nations, the characteristics of each, and other points of particular interest in connection with the picture.

We quote from Mr. Lucas' notes of recent exhibitions:

Pittsburg, Pa.—On June 4 the picture was shown at the Carnegie Institute Lecture Hall under the auspices of the Engineering Society of Western Pennsylvania. This was a special meeting called for the purpose and invited guests were present.

Cleveland, Ohio.—On June 5 the Cleveland Engineering Society called a special meeting at the Chamber of Commerce Auditorium, to which were invited the members of the Cleveland Engineering Society, Chamber of Commerce, Cleveland Advertising Club, West Side Chamber of Industry, City Club and the Superintendents and Foremans Club. While in Cleveland, the 9.2-inch shell was shown at the recruiting station, and as this was registration day, it aroused considerable interest and helped the recruiting work.

Buffalo, N. Y.—The Engineering Society of Buffalo called a special meeting at the ballroom of the Iroquois Hotel on Wednesday evening, June 6. Here several hundred members of the local society and other engineering men of Buffalo gave close attention to the preliminary lecture and the moving picture film. The meeting was preceded by a banquet, which was well attended.

Rochester, N. Y.—On Friday, June 8, the annual meeting of the Rochester Engineering Society was held, at which the lecture and moving picture were given. Owing to the fact that considerable shell work has been done in Rochester, more than ordinary interest was displayed in the film.

At the time of writing this notice—June 23—arrangements have been made to show the picture at various points in New England, and audiences comprising several thousand mechanical executives will probably see the picture between June 23 and 30.

* * *

WIRE STRAIGHTENERS—CORRECTION

The illustrations Figs. 4, 5, 6, 9, 10 and 11 of the article "Wire Straighteners" in the June, 1917, number showed straighteners made by the F. B. Shuster Co., New Haven, Conn. The statement in the description of Fig. 9 to the effect that the upper rolls are mounted in an equalizing block, and the lower rolls are fixed, is incorrect. The rolls are independently adjustable.

PERSONALS

Walter F. Sheehan has been appointed general manager of the Globe Motor Truck Co., St. Louis, Mo.

Henry Prentiss of Henry Prentiss & Co., Inc., New York City, has been elected president of the Machinery Club of New York.

R. E. Uptegraff has taken a position as chief engineer in the transformer department of the Packard Electric Co., Warren, Ohio.

C. T. Schaefer has been engaged by the Globe Motor Truck Co., St. Louis, Mo., as chief engineer. He was formerly chief engineer of the Mogul Truck Co.

M. M. Moore, formerly with the machine tool department of Gaston, Williams & Wigmore, Inc., New York City, is now employed in the sales department of John W. Thorne & Co., Inc., 165 Broadway, New York City.

Major Fred. H. Moody, mechanical editor of the *Railway and Marine World*, Toronto, Canada, and formerly associate editor of MACHINERY, is recovering from a shell wound in the arm received "somewhere in France."

Robert R. Keith, for the past five years in charge of the Sheffield plant of the Fairbanks-Morse Co. at Three Rivers, Mich., has taken a position as plant manager of the Holt Mfg. Co., Peoria, Ill., manufacturer of the "Caterpillar" gas tractor.

J. B. Ennis, who has been chief mechanical engineer of the American Locomotive Co. since 1912, has been appointed vice-president of the company in charge of engineering. Mr. Ennis has been with the American Locomotive Co. since its incorporation in 1901, prior to which he was with the Rogers Locomotive Works and the Schenectady Locomotive Works.

Alfred Spangenberg has resigned his position as assistant superintendent of the machine shop of the S. L. Moore & Son Corporation, Elizabeth, N. J., and is now superintendent of the ordnance shop of the Mead, Morrison Mfg. Co., East Boston, Mass. Mr. Spangenberg was for about twelve years with the Pond Works of the Niles-Bement-Pond Co., at Plainfield, N. J.

Morris R. Machol, sales manager of the Speco Manufacturing Corporation, New York City, read a paper, "Spark Gaps in Series with Spark Plugs," at the tenth annual convention of the National Gas Engine Association in Chicago, June 7. The paper described a spark gap device that eliminates many of the faults of spark plugs due to carbon, defective insulation, etc.

Robert Wuest, who for many years was the commissioner of the National Metal Trades Association, has joined the Travelers Insurance Co., Hartford, Conn., as a specialist in group insurance, with headquarters in Cincinnati. Mr. Wuest traveled extensively following his resignation as commissioner of the National Metal Trades Association. During his sojourn in Great Britain and Germany he gave a great deal of study to social insurance.

Lawrence Allison of Kansas City, Mo., a graduate of the Kansas College of Engineering, who has had ten years' experience in building airplanes with the Curtiss Co., the Standard Co. and the Burgess Co., has been made chief engineer of the Lawson Aircraft Co., Green Bay, Wis., a new concern recently organized by Alfred W. Lawson. John Carisi of Brooklyn has been appointed factory superintendent, and Lee Wallace, chief designer.

A. E. Martell, who until recently was connected with the Southwark Foundry & Machine Co., Philadelphia, Pa., builder of the Southwark-Harris Diesel type oil engine, is now associated with Leonard B. Harris, consulting engineer and architect, with offices at 411 Walnut St., Philadelphia, Pa. Mr. Martell, besides being an oil engine specialist, has had a broad experience in the design of automatic machinery, jigs, tools and fixtures for quantity production.

Ainslie A. Gray and Charles L. Benjamin, well-known advertising managers, have joined forces and will maintain offices at 301-302 Transportation Bldg., Chicago, and 608 S. Dearborn St., Chicago, where they will act as advertising counsel to manufacturers of electrical, mechanical, chemical and kindred products; they will analyze and report upon problems of manufacture and distribution and will supervise the preparation of advertising copy for trade papers, catalogues, booklets, etc.

A reunion in honor of the eighty-fifth birthday of Amos Whitney, of Hartford, Conn., one of the founders of the Pratt & Whitney Co. and secretary and treasurer of the Whitney Mfg. Co., was held at the Farmington Country Club, June 20. An informal dinner was given at the club. Among those present were George Bardons, George A. Bates, George M. Bond, W. J. Belcher, W. H. Carter, W. L. Cheney, William Corey, William Coffey, Charles Church, Charles Davis, George F. Echols, A. W. Foote, James W. Greene, B. M. W. Hanson, Herbert Hastings, W. H. Honiss, Frank Harrington, John Johnston, J. N. Lapointe, W. A. Lorenz, Thomas Mannix, C. E. Randles, George Reynolds, John Reynolds, L. E. Rhodes, Ambrose Swasey, Charles W. Sponsel, W. W. Totman, C. F. Tucker, W. R. Warner, C. E. Whitney, George O. Whitney, Fred A. West, Fravel Woodworth.

OBITUARIES

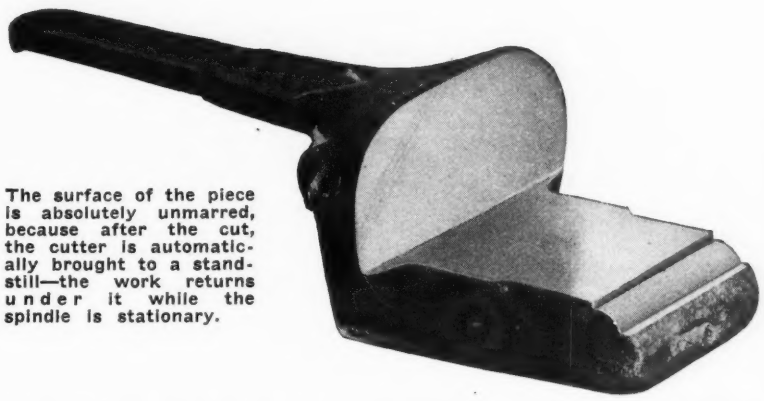
A. Vanderbeek, proprietor of the Vanderbeek Tool Works, Hartford, Conn., whose death took place on May 9 last, was in the wholesale grocery business in Newark, N. J., many years ago. He retired from that business and took up the manufacture of a milling machine which he worked at for a number of years, meantime moving to Hartford, Conn. The milling machine was not a commercial success, and he then took up the manufacture of universal joints and handy vises, which he continued up to the time of his death. The business has now been taken over by the Ainslee Machine & Tool Works, Hartford, Conn., who will continue it.

CINCINNATI AUTOMATIC MILLERS

With Intermittent Feed and Automatic Spindle Stop For Manufacturing

RIFLE AND MACHINE GUN COMPONENTS

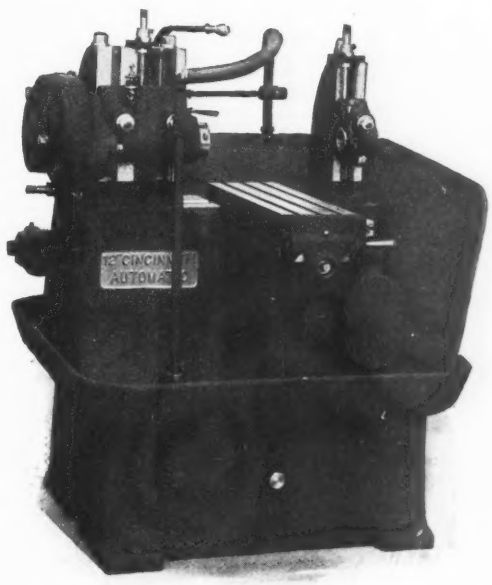
and Similar Parts in Quantities



The surface of the piece is absolutely unmarred, because after the cut, the cutter is automatically brought to a standstill—the work returns under it while the spindle is stationary.

They have the intermittent feeding feature, which has proven so successful on our earlier machines, with this addition — after the cut is taken the spindle is stopped automatically so that the work returns beneath it while the cutter is stationary—no danger of marring the surface of the work because of a revolving cutter.

Consider, too, the advantage of this from the standpoint of safety. The operator removes the finished piece and chucks a new one while the cutter is stationary. He can't get caught by a swiftly revolving although idle cutter. After he chucks the new piece, he moves one lever—and immediately both the spindle and feed movements start again.



This is one improvement on the Cincinnati Automatic. There are others equally vital. Do you wonder this new machine has already made a place for itself in the esteem of a number of big munitions shops?

For manufacturing parts in quantities it offers exceptional advantages.

Bulletin containing details will be sent you upon request.

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI, OHIO

COMING EVENTS

July 26—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

August 30-September 1—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill.; Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

September 10-15—Annual convention of the National Safety Council, New York City; Hotel Astor, headquarters. Marcus A. Dow, president, Grand Central Station, New York City.

September 10-15—Exposition of safety appliances at the Grand Central Palace, New York City, under the auspices of the American Museum of Safety, 18 W. 24th St., New York City. Arthur H. Young, director.

September 27-29—Informal congress and reunion of American and Canadian engineers and architects of Norwegian birth or descent in Chicago at Chicago Norske Klub, 2346 N. Kedzie Blvd., Logan Square, Chicago, Ill.

SOCIETIES, SCHOOLS AND COLLEGES

Melbourne Technical School, Workingmen's College, Melbourne, Australia. Prospectus for 1917, containing admission requirements, calendar, outline of courses, etc.

Committee for Men Blinded in Battle, 111 E. 59th St., New York City, has issued a report of its work in France during the past two years. The report gives an account of some of the remarkable work that has been accomplished in training the blind to take up useful work. Some of the things that have been taught, besides Braille, are typewriting, stenography, commercial courses, languages, music, handicrafts, modeling, sports, games, etc.

Cleveland Engineering Society, Cleveland, Ohio, has issued a publication named "The Conquerors," which is offered as a contribution to the work of the committee on cooperation. It aims to give credit to the engineer for services to society in conquering the forces of nature and bending them to the service of man. The following articles appear: "Peacefulness and Greatness of the Earliest Engineers," by George H. Johnson; "Making Homes in the Desert," by F. H. Newell; "Public Water Supply," by George W. Fuller; "Transportation," by A. W. Johnston; "Some Notable Masonry Bridges," by Henry S. Jacoby; "Measurement of Steam Flow by the United States Geological Survey," by John C. Hoyt; "Recent Developments in Naval Architecture," by Charles F. Gross. The price of the publication is 25 cents.

NEW BOOKS AND PAMPHLETS

Summary of Report on Workmen's Compensation Acts in the United States. 8 pages, 6 by 9 inches. Published by the National Industrial Conference Board, Boston, Mass.

The Embrittling Action of Sodium Hydroxide on Soft Steel. By S. W. Parr. 57 pages, 6 by 9 inches; illustrated. Published by the University of Illinois, Urbana, Ill., as Bulletin 94 of the Engineering Experiment Station. Price, 30 cents.

Magnetic and Other Properties of Iron-Aluminum Alloys Melted in Vacuo. By Trygve D. Yensen and Walter A. Gatward. 54 pages, 6 by 9 inches; 19 illustrations. Published by the University of Illinois, Urbana, Ill., as Bulletin 95 of the Engineering Experiment Station. Price, 75 cents.

Foreign Commerce and Navigation of the United States for the Year Ending June 30, 1916. 950 pages, 9 by 11½ inches. Published by the Department of Commerce, Washington, D. C.

This volume gives the total values of imports and exports of merchandise, gold and silver, and the tonnage of vessels entered and cleared for each year from 1912 to 1916. Various grouping arrangements are made so as to make the book of the greatest statistical value possible.

Examples in Battery Engineering. By F. E. Austin. 90 pages, 4¾ by 7½ inches; 39 illustrations. Published by Prof. F. E. Austin, Hanover, N. H. Price, $1.25.

The general and increasing use of primary and storage cells makes this work on battery engineering of general value to engineers and others concerned with problems of battery design and maintenance. The work is divided into sixteen lessons that were used in the author's classes. The lessons are accompanied by examples and problems which illustrate the principles explained.

Statistical Abstract of the United States, 1916. 773 pages, 6 by 9 inches. Published by the Department of Commerce, Bureau of Foreign and Domestic Commerce, Washington, D. C. Price, 50 cents.

The American statistics cover such subjects as agriculture, forestry and fisheries; manufacturing and mines; internal communication and transportation; merchant marine and shipping; foreign commerce; consumption estimates; prices; money, banking and insurance. Commercial, financial and monetary statistics of the principal countries of the world are included.

Compressed Air—Theory and Computations. By Elmo G. Harris. 192 pages, 6 by 9 inches; 32 illustrations. Published by the McGraw-Hill Book Co., Inc., New York City. Price, $2.

This excellent work, which was first published in 1910, now appears in the second edition. It gives in comparatively few pages many formulas and a large amount of technical data on compressed air engineering. The author very truly states in his introduction that compressed air is a manufactured product of considerably greater value than the things used and consumed in its manufacture, yet in much of the practice in using compressed air, little attention is given to its efficient use. The user is likely to tolerate waste of compressed air that should be checked to save the coal pile. The work deals with fundamental formulas, measurement of air, friction in air pipes, air compressors, special applications of compressed air, air-lift pumps, receivers and storage of compressed air, fans, centrifugal or turbo-air compressors and rotary blowers.

How to Lay Out Turret Lathe Tools. 135 pages, 6 by 9 inches; 114 illustrations. Published by Alfred Herbert, Ltd., Coventry, England. Price, 2s., 6d. (60 cents).

This book is a handbook for those who design tools for use on turret lathes and automatic turning machines. It is a practical book, intended primarily, of course, for the convenience of people using the Alfred Herbert machines, but also containing many suggestions of value to tool designers who are laying out tools for turret lathes of any make. As stated in the preface of the book, the success of a lay-out of tools for turret lathe practice is dependent on the sound judgment of the designer, which, in turn, can only be based on past experience and familiarity with the best shop practice. It has, therefore, been the intention in this book to lay down the broad principles of design and practice, which, if adhered to, will enable anyone with a fair amount of shop experience to undertake this work with reasonable assurance of success. The book is divided into twenty-five chapters, each taking up some specific phase of the problem of laying out tools for the most effective use of turret lathes.

Shop Expense Analysis and Control. By Nicholas Thiel Ficker. 240 pages, 6 by 9 inches. Published by the Engineering Magazine Co., New York City. Price, $3.

The author states that according to the latest figures furnished by the Federal Trade Commission, only 10 per cent of the 250,000 or more manufacturing plants in the United States have adequate cost finding methods in operation; 40 per cent estimate their costs, and 50 per cent have no basis whatever of knowing what their costs are. The need of a more general understanding of the principles of cost keeping and the establishment of better methods of keeping cost is obvious. The work contains twelve chapters with the following heads: Establishing the Unit of Time as a Basis of Distribution; The Two Main Divisions—Machine Expense and Material Expense; Classification and Interpretation of General Ledger Accounts Pertaining to Production; Distributing Manufacturing Expense to Production Centers and Segregating Power Expense; The Standardization of Rent Expense Distribution; Depreciation, Insurance, Taxes and Interest—Tool, Material and Special Department Expense; The Machine Unit System; Current Variation Ratios for Adjusting Current Costs; Organization; Waste in Manufacturing; Graphic Determination of Costs; and Standard Reports.

Getting the Most Out of Business. By E. St. Elmo Lewis. 515 pages, 5¾ by 8½ inches. Published by the Ronald Press Co., New York City. Price, $2.50.

This interesting work might be called a philosophical treatise on the art of living and doing, and we recommend it to anyone in or out of business who has red blood in his veins as well worth reading. The work is so extensive that in giving a notion of the contents we are confined to a statement of the chapter titles, which are as follows: Thought as a Business Asset; Efficiency and Its Applications; Efficiency and Its Problems; Efficiency and Its Standards; Some Business Policies; Psychology and Common Sense; Efficiency and Common Sense; Doers and Thinkers; The Rule of Thumb; The Rules of Efficiency; The Work of Efficiency; The New Gospel of Commercial Efficiency; The Gift of Perception; Seen on the Way; Those Who Lead; The Religion of Loyalty; Loyalty to Plan and Purpose; Loyalty to Ideals; The N. C. R. School; Standard Practice Instructions; The Sales Manual; Extension of the School Plan; The One-man Fallacy; Rational Business Methods; Scientific Principles Applied to Business; The Executive Organization; The Line and Staff System; Individuality; The Efficient Individuality; According to the Rules; The Basis of Discipline; Discipline for Growth; The Essentials of Discipline; The Basis of Wages; The Wage Plan; Educated Democracy; The Law of Service; The Debt to Society.

Mechanical Equipment of Buildings, Vol. II.—Power Plants and Refrigeration. By Louis A. Harding and Arthur C. Willard. 759 pages, 6¾ by 9 inches; illustrated. Published by John Wiley & Sons, Inc., New York City. Price, $5.

This extensive work is a reference book for building engineers and architects, and is the second part of the treatise, though complete in itself. In order to make Vol. II complete, the chapters on heat, water, steam, air, fuels and combustion, and parts of two other chapters were reprinted from Vol. I. The contents are: Physical Units and the Measurement of Heat; Water, Steam and Air; Fuels and Combustion; Boilers and Rules for Construction; Mechanical Stokers; Superheaters and Economizers; Chimneys for Power Boilers; Mechanical Draft; Feed-water Heaters and Feed-water Purification; Steam Engines; Steam Turbines; Pumps; Steam Condensers; Cooling Ponds and Towers; Pipe, Fittings, Valves, Coverings and Accessories; Power Plant Piping; Arrangement of Steam Power Plants; Coal and Ash Handling Machinery; Isolated Power Plant Data; Cost of Steam and Gas Power Equipment; Units Employed in Refrigeration Practice; Heat Transmission and Construction of Cold Storage Walls; Heat Transmission of Piping as Used in Refrigeration Practice; Methods of Producing Artificial Refrigeration; Cold Air Machines; Compression Machines; Vacuum Machines; Ammonia Condensers; Brine Circulating System; The Ammonia Absorption Machine; Ice Manufacturing Plants. A great amount of tabular matter is included, much of which is especially valuable to refrigerating engineers.

Stobbs' Wire and Sheet Gage Tables and Metal Calculator. By Thomas Stobbs. 95 pages, 4¾ by 7¼ inches. Published by Spon & Chamberlain, New York City. Price, $1.25.

The author states that the tables were compiled to supply a long-felt want by merchants, manufacturers and those connected with the wire, sheet steel and other metal industries. Inasmuch as the metric system is coming more and more into use in England, the author has selected the tenths and hundredths of a millimeter as units, giving the equivalents in decimals of an inch. The work includes: Examples of Calculation for Wide Sheets, Sheet Steel, Circular Plates, Steel Sections; Multipliers for Finding the Net Weight of Rolled Metals; Millimeter Gage with Equivalents in Decimals of an Inch, in Imperial Standard Wire Gage; Stubs and Birmingham Gage, Tenths of a Millimeter and Fractions of an Inch; Imperial Standard Wire Gage, with Equivalents in Decimals of an Inch and in Millimeters; Stubs and Birmingham Wire Gage, with Equivalents in Decimals of an Inch and in Millimeters; Brown & Sharpe's (American) Wire Gage, with Equivalents in Decimals of an Inch and in Millimeters; Whitworth's Decimal Wire Gage, with Equivalents in Millimeters, Nearest Number in Stubs Gage; Needle Wire Gage, with Equivalents in Decimals of an Inch and Millimeters; Music Wire Gage, with Equivalents in Decimals of an Inch, and Nearest Size in Imperial Standard Wire Gage and Stubs Gage; French Wire Paris (P) Gage, with Equivalents in Millimeters and Decimals of an Inch; Japy Wire Gage, with Equivalents in Millimeters and Decimals of an Inch; German Millimeter Wire Gage, with Equivalents in Decimals of an Inch and Nearest Imperial Standard Wire Gage and Stubs Gage; Lancashire Pinion Wire Gage (Letter and Number), with Equivalents in Decimals of an Inch and in Millimeters; Norton's Spindle Sizes, with Equivalents in Decimals and Fractions of an Inch and in Millimeters; Whitworth's Standard Sizes Hexagon Bolts and Nuts, with Equivalents in Decimals of an Inch and in Millimeters; Tables of Ship Plates; Weights of Square, Round, Hexagon, Octagon, Three-square and Half-round Metals, Round Metal Wire, Metal Cubes, Balls and Disks, etc. The limits of space will not permit extending this list of contents, but, needless to say, the book is comprehensive and valuable to all needing an authoritative set of gage tables in English, metric and foreign sizes.

NEW CATALOGUES AND CIRCULARS

Stow Mfg. Co., Binghamton, N. Y. Circular illustrating Stow grinders, flexible shafts, portable drills, etc.

Reliance Electric & Engineering Co., 1056 Ivanhoe Rd., Cleveland, Ohio. Bulletin 2014 of Type T heavy-duty Reliance motors for direct current.

National Lathe Co., 15 W. 2nd St., Cincinnati, Ohio. Circular of the 17-inch, quick-change, double back-geared, three-step cone pulley "National" engine lathe.

Link-Belt Co., Chicago, Ill. Booklet entitled "Blue Diamond Coal Co.'s Tipple," describing the installation made at Cardiff, Ky., by the Link-Belt Co.

Taylor Machine Co., 7804 Carnegie Ave., Cleveland, Ohio. Circular of "Atlas" 20-inch double back-geared lathes, built in 8-, 10- or 12-foot lengths of beds, or longer to order.

Link-Belt Co., Chicago, Ill. Booklet entitled "The Ideal Drive for Grain Elevators," illustrating typical applications of Link-Belt silent chain in new and old grain elevators.

Wright Mfg. Co., Lisbon, Ohio. Catalogue 8 of Wright steel hoists, hand cranes and steel trolleys. Wright high-speed steel chain hoists vary in capacity from ¼ to 30 tons.

Prest-O-Lite Co., Inc., 837 Speedway, Indianapolis, Ind. Catalogue of apparatus for oxy-acetylene welding and cutting. This apparatus is designed for use with high-pressure gases only.

Link-Belt Co., Chicago, Ill. Catalogue 270, illustrating and describing Link-Belt wagon and truck loaders for loading and screening such material as coal, stone, sand, foundry refuse, etc.

David A. Wright, 568 Washington Blvd., Chicago, Ill. Circular of the Pratt & Wright No. 1½ screw machine, having an automatic chuck capacity of 13/16-inch round, 19/32-inch square and 23/32-inch hexagon.

U. S. Electrical Mfg. Co., Los Angeles, Cal. Circular of electric grinding and buffing motors using one-, two- or three-phase current, 110 to 440 volts, and operating at speeds from 1800 to 3600 revolutions per minute.

Dodge Sales & Engineering Co., Mishawaka, Ind. Catalogue C 17A of power transmission machinery, comprising shafting, hangers, pulleys, clutches, collars, couplings, countershafts, pillow blocks, step bearings, floor stands, belt tighteners, binder frames, etc.

Metalwood Mfg. Co., Detroit, Mich. Circular B-50 of Metalwood banding presses for pressing in copper rotating bands on high-explosive shells. These presses are built in two sizes, one for banding 3- to 6-inch shells and the other for banding 7- to 10-inch shells.

The LUCAS

(OF CLEVELAND)

"PRECISION"

BORING, DRILLING AND

MILLING MACHINE

ALWAYS GOOD

and as time goes on

ALWAYS BETTER

LUCAS MACHINE TOOL CO., NOW AND ALWAYS OF CLEVELAND, O., U.S.A.

Link-Belt Co. Chicago, Ill. Booklet entitled "Increasing Profits by Saving Expense in the Handling and Storing of Coal and Ashes." The publication is profusely illustrated with line engravings and halftones showing up-to-date coal and ash handling equipment.

Montgomery & Co., Inc., 104 Fulton St., New York City. "Odds and Ends" No. 7, containing latest prices of the line of tools, supplies and machinery carried by this company, which includes vises, tool chests, drills, gages, faceplates, centers, angle-plates, punches, screws, snips, files, etc.

Steel-Art Tool Co., Elgin, Ill. Circular of the "Satco" quick-change, keyless drill chuck, made in five sizes, having capacities from 0 to ⅝ inch, inclusive; also circulars of the "Satco" adjustable boring- and turning-bar and bar-holder, improved hollow drill, and hollow end-mill with receding center.

Hoskins Mfg. Co., 459 Lawton Ave., Detroit, Mich. Bulletin 3-A on Hoskins pyrometers, high-resistance type. These pyrometers are fitted with Hoskins base metal thermo-couples, made of "Chromel," the characteristic of which is a practically straight-line relation between the temperature rise and the milli-voltage.

Sprague Electric Works of General Electric Co., 527 W. 34th St., New York City. Bulletin 48700 A, descriptive of Sprague electric monorail hoists, cage-controlled, and illustrating installations of monorail hoists in various plants. Tables of ratings and weights of monorail hoists for direct and alternating current are included.

Colburn Machine Tool Co., Franklin, Pa. Circular of the No. 2 Colburn manufacturing heavy-duty drilling machine, 20-inch swing, having capacity to drive 1¼-inch high-speed drills through steel. The circular illustrates details and shows the machines in gangs of four spindles; two- and three-spindle gangs are also furnished.

Metalwood Mfg. Co., Detroit, Mich. Circular B-49, illustrating the Metalwood No. 87 internal pressure physical test press, designed primarily for testing high-explosive shells, but which can also be used for general laboratory and experimental work. An internal hydraulic pressure of 16,500 pounds per square inch is developed.

Greenfield Tap & Die Corporation, Greenfield, Mass. Catalogue containing a detailed description of the "Acorn" die and holder, for which the advantages of strength, accuracy, speed, adaptability and high quality of work are claimed. The catalogue is illustrated with views that show clearly the construction of the die and its use.

Hess-Bright Mfg. Co., Front St. and Erie Ave., Philadelphia, Pa. Pamphlet entitled "The Application of Ball Bearings to the Airplane," by W. L. Batt, mechanical engineer. The pamphlet briefly reviews the development of ball bearings and illustrates several applications of Hess-Bright radial and thrust bearings to airplane propellers.

Hess-Bright Mfg. Co., Front St. and Erie Ave., Philadelphia, Pa. Pamphlet entitled "Hess-Bright Ball Bearings—How to Apply Them," by H. Wickland. Applications of radial ball bearings are illustrated and the conditions to be observed are discussed. The pamphlet should be useful to all designers applying ball bearings in machine design.

De Laval Steam Turbine Co., Trenton, N. J. Catalogue entitled "Progress in Water Works Pumps," which treats of the development and advantages of steam-turbine-driven centrifugal pumps for city water supply, and illustrates installations in fifteen of the principal cities in this country and Canada, including thirty-four units, aggregating 999,000,000 gallons per day capacity.

Union Switch & Signal Co., Swissvale, Pa. Bulletin 87 on the forge plant which has recently been equipped with heavy steam drop-hammers for making forgings for automobiles, tractors, aeroplanes, etc. The fire in February that destroyed the company's main shop did not reach the building occupied by the forge, foundry or power house; hence the capacity to make forgings has not been affected.

Cleveland Twist Drill Co., Cleveland, Ohio, has issued an announcement of sets of "Ezy-out" screw extractors ranging from No. 1, the smallest, to No. 12, the largest. The smaller sizes of these extractors are put up in sets, the tool-room set comprising Nos. 1 to 5, inclusive; the utility set is made up of Nos. 4, 5 and 6; and the heavy shop set of Nos. 6, 7, 8 and 9; Nos. 10, 11 and 12 are sold singly.

Landis Machine Co., Waynesboro, Pa. Catalogue 23 of pipe and nipple threading machines, pipe threading and cutting machines and chaser grinders. The characteristics of the Landis die are illustrated and described, and data are included of clearances, etc., useful to toolmakers who maintain Landis machines in service. The Landis pipe machines are furnished in single- and double-spindle combinations, belt- and motor-driven.

International Machine Tool Co., Indianapolis, Ind. Catalogue of "Libby" turret lathes, a line of heavy-duty turret lathes, capable of forming, facing, turning and boring chucked pieces up to 26 inches in diameter and bar work up to 7¼ inches in diameter. These machines are described at length, the various parts being illustrated in detail. A table of condensed data, giving dimensions, feeds, speeds, etc., of the different sizes of "Libby" lathes, is included.

T. C. M. Mfg. Co., Hunterdon and First Sts., Harrison, N. J. Catalogue of Morris Thomson semi-automatic thread milling machine, made in five sizes or styles. Type 12-E has a capacity of 12 inches diameter by 42 inches long; Type 6-C, capacity 6 inches diameter by 34 inches long; Type 2-D, capacity 2 inches diameter by 9 inches long; Type 3-B, single-purpose for milling threads in base ends and noses of 3-inch shells; Type 1-A, capacity 1¼ inch diameter by 36 inches long, or 2 inches diameter by 9 inches long.

Lincoln Electric Co., Cleveland, Ohio. Pamphlet on "Electric Arc Welding," reviewing the various methods of welding and dealing with electric arc welding in particular. The pamphlet is profusely illustrated and contains valuable data and suggestions for welding engineers and operators. The possibilities of reclaiming defective steel castings are shown convincingly. Examples of broken gray iron and malleable castings, broken locomotive frames, cracked boiler sheets, leaky rivets, broken crossheads and other characteristic railway repair work are given, with data on labor, material and current cost and costs of other methods. Equipments suitable for various classes of electric arc welding are illustrated.

Gardner Machine Co., Beloit, Wis. Catalogue of grinding and polishing machinery, accessories and supplies, comprising disk grinders for metals, disk grinders for pattern shops, disk grinder accessories, ring wheel grinders, band finishing machines, polishing and buffing lathes, ring wheel chucks, fixtures for disk grinders, abrasive disks, cloth and paper, wheel cement and disk grinder grease. The development of the disk grinding machine during the past ten years has been rapid, and it is now regarded as indispensable for many operations, having achieved the position of a high-grade machine tool in manufacturing establishments. The catalogue illustrates an extensive line of disk grinding machines, belt- and motor-driven, with one and two spindles provided with either plain or ball bearings to take radial and thrust loads. An extensive line of pattern makers' disk grinders and attachments is shown; also polishing lathes provided with ball bearings.

TRADE NOTES

L. S. Starrett Co., Athol, Mass., will appear prominently in the large electric display of the Rice Leaders of the World Association in New York City.

Westinghouse Electric & Mfg. Co. and the Westinghouse Machine Co. were merged by vote at the annual meeting of the stockholders in East Pittsburg, June 13.

Van Dorn Electric Tool Co., Cleveland, Ohio, has opened a branch office at 524 Wells Bldg., Milwaukee, Wis., under the management of James Gibbons, formerly manager of the company's Baltimore office.

Union Switch & Signal Co., Swissvale, Pa., is installing 5000-pound steam drop-hammers which will largely increase the facilities for forging automobile axles, large gear blanks, crankshafts and cam-shafts.

Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass., combined a flag raising with a "Liberty" bond sale May 25, at which time 173 employes subscribed to a total of approximately $30,000 worth.

Axelson Machine Co., Los Angeles, Cal., has moved to its new factory, comprising seven large and spacious buildings, up to date in all particulars. The concern is one of the largest manufacturers on the Pacific coast.

Driggs-Seabury Ordnance Co., Sharon, Pa., has acquired all the property and assets of the Savage Arms Co., Utica, N. Y., and has changed its name to the Savage Arms Corporation. The offices of the corporation are at 50 Church St., New York City.

Inter-State Machine Products Co., Inc., Rochester, N. Y., has opened an automatic screw machine department for handling outside work, and has installed a number of new four-spindle automatic screw machines. The department is expected to be running July 1.

Manufacturers' Equipment Co., Chicago, Ill., maker of air chucks, air cylinders and other labor-saving devices, has opened an office in New York City at 30 Church St., with E. J. Chamberlin in charge. The New York office was opened in order to give better service to the company's customers in the East.

Twentieth Century Brass Works, Minneapolis, Minn., are erecting a brick building, 65 by 66 feet, two stories and basement, at 518 Fifth Ave., S., which will be occupied about July 1. Considerable equipment will be installed. The company operates a brass, bronze and aluminum foundry, machine shop for brass finishing and special manufacturing.

Foster Machine Co., Elkhart, Ind., manufacturer of turret lathes and tool equipment, is erecting additions to the plant that will increase the floor area 100,000 square feet. The company expects to make other additions soon to provide facilities for the new line of turret lathes. The plant is up to date, being equipped with modern machinery throughout. Oskar Kylin is the chief engineer.

Navy Department, Bureau of Yards and Docks, Washington, D. C., has called for sealed proposals to specification No. 2362 for power plant equipment at the Naval Training Station, Newport, R. I., the early completion of which is of the utmost urgency. Bids are requested for furnishing and installing turbo alternators, condensers, pumps, exciters, boilers, stokers, draft fans and piping.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., granted another advance in wages to its employes May 16, amounting to 10 per cent, making a total increase in a period of two years of about 40 per cent. The company has also subscribed for a number of Liberty bonds, which it offers to its employes, permitting them to pay for them in small monthly or semi-monthly installments.

Vanadium-Alloys Steel Co., Latrobe, Pa., with sales offices in Pittsburg, Pa., has purchased $100,000 worth of Liberty bonds, and will also purchase all the bonds subscribed for by its employes, permitting payment on easy terms covering a period of approximately one year. No interest charge will be made, and upon final payment the bonds will be delivered to the employes with all coupons attached.

McMeehan Engineering Staff, East Providence, R. I., is an organization composed of several production men and designers who have held, or are holding responsible positions with reputable machinery concerns. The company proposes to render engineering service by making designs, drawings, working out details and specializing in the design of automatic and special machinery, jigs, fixtures and production tools.

Chicago Flexible Shaft Co., Chicago, Ill., manufacturer of flexible shaft machinery, gas and oil furnaces, has built a one-story plant with sawtooth roof about 490 feet long and 300 feet wide at 12th St. and 56th Ave., and expects to occupy it in the month of July. The interior will be arranged by departments, so as to facilitate the economical handling of the various products. The floor is of concrete construction throughout.

Detroit Pneumatic Chuck Co., Flat Rock, Mich., has been reorganized with increased capital. The new officers are Floyd Bryant, president; George Case, vice-president; and George Bunte, secretary, treasurer and general manager. J. A. Olson is superintendent. This company has an up-to-date plant and is bringing out a full line of pneumatic equipment—chucks, mandrels and special tools. The company reports a rapidly growing business.

James H. Matthews & Co., 3942-3946 Forbes St., Pittsburg, Pa., gave its third annual outing and picnic to its employes and friends, at Homestead Park, June 9. The athletic events took up the forenoon, and after the picnic dinner a hotly contested ball game was played, following which was dancing. The event was enjoyable, and profitable in the sense that it brought about personal contact and acquaintance not to be realized in ordinary business relations.

Nicholson File Co., Providence, R. I., manufacturer of files, announces that it will participate in an electric display which is now being erected in New York City overlooking Times Square. This display will be unique. The emblem of the Rice Leaders of the World Association will be represented on the mammoth structure and the names and individual selling points of the members, including the Nicholson File Co., will appear on the display in brilliant electric letters.

Henry & Wright Mfg. Co., Hartford, Conn., manufacturer of automatic drilling machines, has made a contract with the Travelers Insurance Co. to provide $1000 life insurance on the group plan for all its employes. More than one hundred men profit by this at the outset, and many more will be included when they have completed three months' service. The plan went into effect June 1. The certificates not only provide $1000 life insurance, but also contain the usual disability clause.

American Machine Tool Engineering Works, 4854-4858 W. Kinzie St., Chicago, Ill., have taken over the entire "Neat" lathe business of the National Engineering & Tool Works, Oak Park, Ill., and will continue to manufacture this lathe under its trademark "Amtew." Frank W. Hack, general works manager, organized the National Engineering & Tool Works, and was formerly its president. He resigned January 1 and organized the American Machine Tool Engineering Works. A number of improvements are being made in the lathe.

General Electric Co., Schenectady, N. Y., has moved its New York City offices from 30 Church St. to the Equitable Bldg., 120 Broadway. The entire twentieth floor of the building has been especially arranged and furnished for the company. In the quarter century since the company was formed, its business has increased from about $10,000,000 in gross sales the first year of its organization to gross orders of over $167,000,000 during the twenty-fifth year, and its sales offices have naturally increased in number and importance. The offices in New York City are the largest and most important among its district offices.

Driver-Harris Wire Co., Harrison, N. J., has changed its name to the Driver-Harris Co. The former name did not comprehensively designate the products of the concern, which comprise not only wire but also alloys and pure metals in the form of strips, rods, sheets and castings. The company also manufactures flexible heater cords and wire rope. It has issued in bulletin form a new catalogue covering the complete line of products, with the exception of resistance materials, which are covered in the regular resistance catalogue. The new bulletins include monel metal, pure nickel, wire rope, heater cord, cold-rolled steel strip, brass, bronze and phosphor-bronze wire and "Nichrome" castings.

American Steel Export Co., Woolworth Bldg., New York City, has for over a year been devoting much energy to the upbuilding of its corps of representatives. Thirty have been established in the trade centers of the world, and others will be added as new territories are taken up for development. F. H. Tackaberry has been appointed traveling representative with the title of general agent. He was recently associated with the Ordnance Engineering Corporation of New York City and has held important executive positions in the Industrial Underwriters Inc., the Locke Steel Belt Co., etc. Mr. Tackaberry's first trip will be to South America, Brazil being his immediate objective and Rio de Janeiro his first base of operation.

Buffalo Forge Co., Buffalo, N. Y., has received an order from the National Acme Co., Cleveland, Ohio, for the installation of heating and ventilating equipment which will be the largest of its kind in a building under one roof, heated and ventilated by the fan system. The equipment consists of four "Carrier" Type A air washers with automatic control and fresh and return air dampers; four "Niagara" conoidal supply fans, two of which deliver 100,000 cubic feet of air per minute each and two 95,000 cubic feet of air per minute each; four exhaust fans, two of which will handle 70,000 cubic feet of air each and two 50,000 cubic feet of air per minute each; ten "Baby" conoidal fans; about 27,000 feet of "Vento" and four 12- by 14-inch steam engines for driving the fans.